CLARK FORK BASIN PERIPHYTON MONITORING:

AN ASSESSMENT OF BIOLOGICAL INTEGRITY AND IMPAIRMENT BASED ON ALGAE ASSOCIATIONS DURING AUGUST OF 2001

prepared for:

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SUMMARY

Periphyton (benthic algae) samples were collected from natural substrates at 28 locations on the Clark Fork of the Columbia River and major tributaries during early August of 2001 by a contractor for the Montana Department of Environmental Quality (DEQ), Planning, Prevention and Assistance (PPA) Division. This monitoring was conducted for the purpose of assessing water quality, biological integrity and overall impairment of aquatic life as part of the ongoing Clark Fork Basin Project. Similar algae surveys have been conducted annually by the State of Montana since 1986.

Samples were analyzed for relative abundance of non-diatom algal genera, dominant non-diatom phylum, and relative abundance of diatom species. The total percent relative abundance of diatom species in each of three pollution tolerance groups were calculated. Diatom metrics calculated included: diatom species richness, Shannon species diversity, pollution index, siltation index and percent similarity index. An assessment protocol utilizing specific criteria based on diatom metrics was used to determine biological integrity, overall impairment of aquatic life and degree of support of aquatic life beneficial uses at each station monitored during 2001.

During August 2001, monthly mean streamflows throughout the Clark Fork Basin were well below average for the twelve year period of record for periphyton monitoring due to extended drought.

Blacktail Creek, the principal headwater tributary to Silver Bow Creek, had good biological integrity with minor aquatic life impairment, and fully supported beneficial uses. Diverse non-diatom and diatom algae indicated relatively unimpaired water quality during August 2001.

Silver Bow Creek (SBC) above the Butte wastewater treatment plant (WWTP) had good biological integrity with minor impairment of aquatic life, while SBC downstream of the WWTP and Superfund Lower Area One (the former Colorado Tailings site) exhibited poor biological integrity with severe overall impairment of aquatic life and nonsupport of beneficial uses during August 2001. SBC above the Warm Springs Ponds at Opportunity had fair biological integrity with moderate aquatic life impairment and partial support of beneficial uses. Elevated levels of biogenic wastes, nutrients, sediment and heavy metals continued to seriously impact this reach. Significant improvement above the Butte WWTP was apparent during 2001 as a result of recent Superfund remediation efforts. Good biological integrity with minor impairment of aquatic life and full support of beneficial uses was indicated at the Silver Bow Creek downstream of the Warm Springs Ponds in 2001. The pond system continues to effectively trap and buffer pollutants from upper Silver Bow Creek.

The station on the Mill-Willow Bypass was re-established in 1999 on the reconstructed channel near Warm Springs. Biological integrity was good, with only minor aquatic life impairment in August 2001, indicating very good water quality and full support of beneficial uses.

Warm Springs Creek had good biological integrity with minor impairment of aquatic life indicated during August 2001, based on a slightly elevated siltation metric. However, other diatom and non-

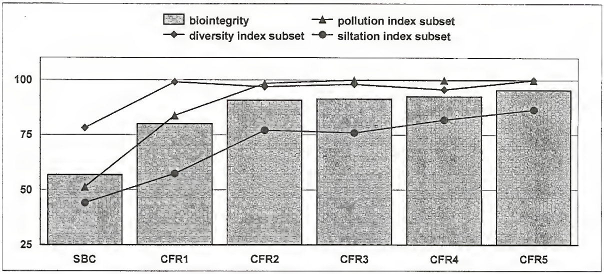
diatom metrics suggested an unimpaired biota in Warm Springs Creek, and good water quality in this important tributary to the upper Clark Fork.

Biological integrity in the Clark Fork between Warm Springs Creek and the Little Blackfoot River was generally good, with one station above Deer Lodge rated as fair during August 2001. Sediment was indicated as the principal cause of minor impairment of aquatic life through this reach, with nutrients and physical stress also contributing to moderate impairment above Deer Lodge.

Biological integrity in the Clark Fork between the Little Blackfoot River and Blackfoot River was generally good throughout the reach, with full support of beneficial uses and only minor impairment of aquatic life during August 2001 due to sediment impacts. Minor impairment of aquatic life was indicated in the Little Blackfoot River, and moderate impairment indicated in Flint Creek during August 2001. Rock Creek and the Blackfoot River had excellent biological integrity with unimpaired aquatic life and full beneficial use support during 2001. The Clark Fork stations at Turah and above Missoula were rated as having good biological integrity with only minor aquatic life impairment due to siltation.

In the Clark Fork downstream of Missoula, minor impairment was indicated below the Missoula wastewater treatment plant. Moderate impairment of aquatic life was indicated at Harper Bridge, below the Bitterroot River, due to sediment, although other metrics rated this reach unimpaired. The Bitterroot River had fair biological integrity and moderate impairment of aquatic life due to sediment, and only partially supported beneficial uses in August 2001. This may be related to areas ravaged during the extreme 2000 fire season. The Clark Fork at Huson was rated as having good biological integrity in 2001, with only minor aquatic life impairment, indicating little if any impacts related to the Smurfit-Stone pulp mill near Frenchtown. Lower Clark Fork stations, above and below the Flathead River, fully supported beneficial aquatic life uses, with little or no impairment indicated in August 2001.

Figure S1. Longitudinal trends - Mean biointegrity (%) at stream reaches in the Clark Fork Basin during August 1989 - 2001. Values are percent of total possible score, as the mean of impairment ratings (from 1 to 4) assigned to each data set over 13 years.



Stream reaches: SBC = Silver Bow Creek; CFR1 = Clark Fork from Warm Springs Creek to Little Blackfoot River; CFR2 = Clark Fork from Little Blackfoot River to Turah; CFR3 = Clark Fork from Blackfoot River to Bitterroot River; CFR4 = Clark Fork from Bitterroot River to Alberton; CFR5 = Clark Fork from Alberton to Flathead River

Longitudinal trends in mean biological integrity for stream reaches in the Clark Fork Basin over the thirteen years 1989-2001 are plotted in Figure S1. Biointegrity, and the diversity, pollution and siltation index subset values, are the means of impairment rating scores assigned under bioassessment Protocol I (Bahls 1993), which range from 1 to 4, with 1 = severe impairment, 2 = moderate, 3 = minor, 4 = no impairment. Values are expressed as a percentage of the maximum possible mean score of 4. Biointegrity is calculated as the mean of all three subset values. Biointegrity was poorest over the last thirteen years in the Silver Bow Creek and upper Clark Fork (CFR) reach, and improved with distance downstream. Low siltation index values strongly influenced biointegrity by depressing the mean. Diversity index approached 100 percent in the upper CFR1 reach, while the pollution index subset was nearly 100 percent at CFR2 and downstream.

Temporal trends are assessed using mean values for impairment rating scores in each subset, and as a total of all subsets, again expressed as a percentage the maximum possible score of 4, determined sequentially over thirteen years for all Silver Bow Creek stations (Figure S2) and for all Clark Fork mainstem stations (Figure S3). Figure S2 shows relatively constant biointegrity at Silver Bow Creek stations, with a definite improving trend indicated over the last four or five intervals. The siltation index subset for Silver Bow Creek suggests steady improvement over the period of record, while the diversity index and pollution index subsets have improved over the last half the period (Figure S2). The Clark Fork mainstem stations (Figure S3) had very constant mean

biointegrity through the sequence, with a decline and subsequent improvement in the siltation index, and an opposite less-pronounced trend in the pollution index and diversity index subsets over the period of record (Figure S3).

Figure S2. Temporal trends - Mean sequential biointegrity (%) in Silver Bow Creek during 13 years of monitoring (1989-2001).

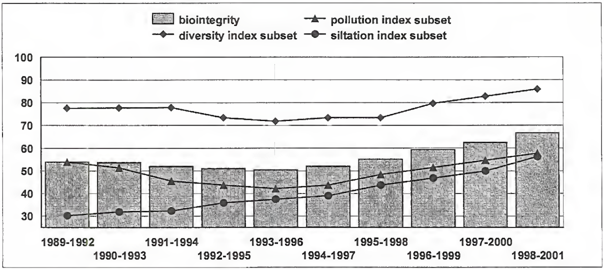
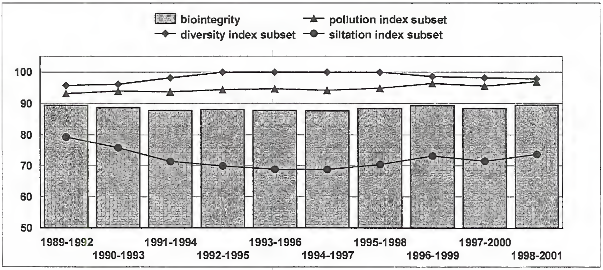


Figure S3. Temporal trends - Mean sequential biointegrity (%) in the Clark Fork during 13 years of monitoring (1989-2001).



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INTRODUCTION

In August of 2001, the Montana Department of Environmental Quality (DEQ) - Planning, Prevention and Assistance (PPA) Division contracted for benthic algae surveys to be conducted at 28 sites on the Clark Fork of the Columbia River and selected tributaries as part of the ongoing Clark Fork Basin Monitoring Project. Similar surveys have been conducted annually by DEQ (and its predecessor DHES) since 1986 (Bahls 1987 and 1989; Weber 1991, 1993, 1995, 1996, 1997, 1998, 1999, 2000 and 2001).

This report presents the results of analyses performed on periphyton samples collected during the 2001 monitoring. Various metrics are employed to assess water quality and biological integrity at the stream sites surveyed. Longitudinal and temporal trends in water quality and biological integrity are also evaluated. Bahls (1993) states: "The concept of biological integrity is the basis for biological assessment and the setting of ecological goals for water quality." As defined by Karr and Dudley (1981): "Biological integrity is the ability of an aquatic ecosystem to support and maintain a ... community of organisms having species composition, diversity, and functional organization comparable to that of the natural habitats within a region." **This definition makes the explicit assumption that natural, undisturbed systems are better than those affected by human activities.**

Periphyton is the assemblage of small, often microscopic organisms (microinvertebrates, bacteria, fungi, and benthic algae) that occur in aquatic habitats, and live attached to or in close association with the surfaces of submerged substrates. Benthic algae typically dominate the periphyton community in freshwater streams. These algae can be divided into two major groups: diatom algae, which possess a rigid siliceous cell wall, or "frustule," and the non-diatom or soft-bodied algae, which lack a siliceous cell wall. The taxonomy of both groups has been well established. Because the shape and ornamentation of diatom frustules are unique to individual taxa, diatoms are readily identifiable to species. It is generally impractical to identify non-diatom algae below the genus level.

Algae, and particularly the diatoms, are useful as biomonitors of water quality because they occur in very large numbers, are highly sensitive to physical and chemical factors, and have known environmental requirements and pollution tolerances unique to individual species (Bahls 1989). Plafkin et al. (1989) lists several other advantages of using algae for bioassessment:

- Algae generally have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts. (Perennial and fossil algae, including expired but recognizable algae within the periphyton matrix, reflect longer term impacts).

- As primary producers, algae are most directly affected by physical and chemical factors.

- Sampling is easy, inexpensive, requires few people, and creates minimal impact to resident biota.

- Relatively standard methods exist for evaluation of functional and non-taxonomic structural characteristics (e.g., biomass and chlorophyll) of algal communities.

- Algal communities are sensitive to some pollutants which may not visibly affect other aquatic communities, or may only affect other communities at higher concentrations (e.g., herbicides and inorganic nutrients).

Generally, periphyton collected from a particular stream location will reflect the environmental conditions that existed there for up to several weeks prior to sample collection. However, many factors in addition to water quality affect the types and amount of algae present at a given time. These include but are not necessarily limited to: streamflow extremes, substrate scour, variable recolonization rates, normal seasonal succession, and sloughing of algal biomass late in the season. Any bias introduced by factors not directly related to water quality can be minimized by sampling at the same time each year, well after the spring spate but before major sloughing of algal biomass occurs in late summer and early fall. Monitoring conducted during the month of August appears to satisfy the aforementioned criteria. Additionally, it likely encompasses the period of poorest seasonal water quality and maximum environmental stress on stream biota due to low streamflow, elevated water temperature, and minimum instream dilution of pollutants and wastewater discharges.

METHODS

Periphyton was collected at 28 monitoring stations on the Clark Fork and selected tributaries in 2001 (Table 1 and Figure 1). The Clark Fork at Huson (station 22), inaccessible in 2000 due the extreme fire danger, was again included in the 2001 monitoring.

Sampling was conducted August 4-8, 2001, about 10 days earlier than the previous year. A single composite periphyton sample was collected from natural substrates at each of the stations by Erich Weber of *Phyco*Logic, according to Procedure 6.2.2 (Periphyton) in the Water Quality Division's Field Procedure Manual (DHES 1989) and section 6.1.1 of Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers (Barbour *et al.* 1999).

Each sample was processed and analyzed by the author in the following manner: A subsample of periphyton from each station was examined under an Olympus BHT compound microscope at 200X and 400X magnifications, and all soft-bodied (non-diatom) algae present were identified to genus. The relative abundance of cells belonging to each genus was estimated using the following system:

- R (Rare): Fewer than one cell per microscope field at 200X, on the average;

- C (Common): At least one, but fewer than five cells per field of view;

- VC (Very Common): Between 5 and 25 cells per field of view;

- A (Abundant): Greater than 25 cells per field of view, but numbers within limits reasonably counted;

- VA (Very Abundant): Number of cells per field too numerous to count.

The abundance of diatom algae (all genera collectively) relative to the non-diatom taxa was estimated for comparative purposes.

Non-diatom genera that ranked common or greater in estimate relative abundance were considered dominant taxa. Each dominant taxon, as well as the diatom component if it met this criterion, was ranked according to its estimated contribution to the total algal biovolume present in the sample. The taxon contributing the greatest biovolume was ranked number 1, the second most number 2, and so on. These rankings were used to calculate the dominant non-diatom phylum (see Non-Diatom Algae Metrics, below).

Following analysis of non-diatom algae, organic matter was chemically oxidized from each sample. A permanent strewn mount of the cleaned diatom frustules was prepared on a glass microscope slide according to "Standard Methods" (APHA et al. 1980). Each permanent mount was thoroughly scanned under a 1000X, 1.25 N.A. oil immersion objective, and all diatom algae encountered identified to species. A proportional count of approximately 800 diatom valves (400 frustules) was performed on each permanent mount, and the percent relative abundance (PRA) of each diatom species was calculated. Diatom species identified during the floristic scan but not encountered during the proportional count were tallied as a single valve and included in metric calculations. In previous years these taxa were designated only as "present" with a letter "p".

Each diatom species was assigned to one of the three groups originally defined by Lange-Bertalot (1979) based on the species response to organic (biogenic) pollution. Simply stated, **group 1** taxa are most tolerant of pollution, **group 2** taxa less tolerant, and **group 3** most intolerant of (or sensitive to) pollution. Bahls (1993) published expanded autecological criteria for assigning diatom taxa to pollution tolerance (PT) groups, along with an extensive listing of diatom taxa reported from Montana. He also determined default PT group assignments, by genus, for taxa lacking sufficient autecological data. A number of unlisted taxa were assigned to PT groups by the author, based on updated autecological data in references by Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b) and Lange-Bertalot (1993). Default PT group assignments were used only as a last resort.

Table 1. Periphyton sampling locations for Clark Fork Basin Project, August 2001.

Station Number	Stream and Site name
SF-1	Blacktail Creek (BTC) above Grove Gulch
00	Silver Bow Creek (SBC) above Butte Metro Wastewater Treatment Plant (WWTP)
01	Silver Bow Creek at Rocker, below Lower Area One (former Colorado Tailings site) and Butte Metro WWTP
2.5	Silver Bow Creek at Opportunity
MW2	Mill Creek-Willow Creek Bypass (MWB) near mouth
4.5	Silver Bow Creek below Warm Springs Ponds
06	Warm Springs Creek (WSC) near mouth
07	Clark Fork (CFR) below Warm Springs Creek
08	Clark Fork near Dempsey
8.5	Clark Fork at Sager Lane
09	Clark Fork at Deer Lodge
10	Clark Fork above Little Blackfoot River
10.2	Little Blackfoot River (LBR) near mouth
11	Clark Fork at Gold Creek Bridge
11.5	Flint Creek (FTC) at New Chicago
11.7	Clark Fork at Bearmouth
12	Clark Fork at Bonita
12.5	Rock Creek (RKC) near Clinton
13	Clark Fork at Turah
14	Blackfoot River (BFR) at USGS Station near mouth
15.5	Clark Fork above Missoula
18	Clark Fork at Shuffields (and below Missoula WWTP)
19	Bitterroot River (BRR) near mouth
20	Clark Fork at Harper Bridge
22	Clark Fork at Huson (and below Stone Container Corporation)
24	Clark Fork near Superior
25	Clark Fork above Flathead River
27	Clark Fork above Thompson Falls Reservoir

Non-Diatom Algae Metrics

Metrics applied to soft-bodied or non-diatom algae at each station include: **number of dominant genera, dominant phylum** and **indicator taxa**.

The **number of dominant non-diatom genera** is generally inversely proportional to the degree of pollution in western Montana streams. In least-impaired reference streams from mountain ecoregions in Montana, which included mountain valleys and foothills, Bahls (1993) reported from 1 to 10 (mean 5) dominant non-diatom genera. In pristine waters, low numbers of non-diatom genera generally indicate nutrient-poor conditions. Higher numbers of genera in unimpaired streams may indicate naturally nutrient-rich water, generally determined by the local mineralogy.

The **dominant non-diatom phylum** was determined by calculating the cumulative weighted rank of genera within each phylum based on estimated biovolume. Diatoms were not included in this metric. Briefly, in a sample with x number of dominant non-diatom genera, the genus ranking highest in estimated biovolume scored x points, second highest, x-1 points, and so on. The phylum having the greatest total points was considered dominant based on estimated relative biovolume. Green algae (phylum Chlorophyta) generally increase in abundance where the concentration of available nitrogen is sufficiently high relative to available phosphorus. Where nitrogen is in short supply, blue-green algae (phylum Cyanophyta) often dominate due to the ability of many the Cyanophyta to "fix" atmospheric nitrogen. Bahls et al. (1992) found that blue-green algae dominated the non-diatom flora of Northern Rockies reference streams, while green algae were co-dominant with blue-green algae in streams of the Montana Valley and Foothill Prairies ecoregion. The Clark Fork mainstem is considered to be primarily in the Montana Valley and Foothill Prairies ecoregion, as are the lower reaches of tributary streams included in this monitoring.

Non-diatom algae are utilized as **indicator taxa** wherever specific autecological requirements and preferences can be established from the available literature. However, most non-diatom algal genera contain several to many species that often span a relatively broad range of prefered water quality.

Diatom Metrics

Metrics calculated for diatom associations at each station include **species richness**; the percent relative abundance (PRA) of the **dominant diatom taxon**; **Shannon diversity index**; **pollution index, siltation index, disturbance index** and **similarity index**. Judgement criteria for rating biological integrity, environmental impairment and aquatic use support using these metrics are found in Table 5.

Species richness is a basic indicator of community health and as a rule correlates directly with water quality: as water quality declines, so does the number of species. In general, unpolluted waters in Montana have more than 25 diatom species counted (Bahls 1979). In reference streams from mountain ecoregions in Montana, between 23 and 51 (mean 33) diatom species were counted (Bahls et al. 1992).

The **Shannon diversity index** (Weber 1973) incorporates elements of species richness with equitability, the evenness of distribution of individuals among the species present. High diversity values occur in diatom communities where no taxa are strongly dominant in numbers, generally the case in healthy, unimpaired streams. In diatom communities under environmental stress, the majority of individuals present belong to a relatively small number of taxa, resulting in lower diversity index values. In general, unpolluted waters in Montana have Shannon diversity values greater than 3.00 (Bahls 1979). Diatom species diversity values of between 2.16 and 4.50 (mean 3.58) were found in 21 least-impaired reference streams from mountain ecoregions (Bahls 1993).

The **pollution index** was proposed by Bahls (1993) as a shorthand method of summarizing the information contained in the three pollution tolerance groups of Lange-Bertalot (1979). The index is derived from the decimal fraction of the total PRA of diatom taxa in each pollution tolerance group, multiplied by the respective group number. The sum of these three products is the pollution index. The index will range from 1.00 (all most tolerant taxa) to 3.00 (all most sensitive taxa). Pollution index values of between 2.45 and 2.94 (mean 2.72) were determined by Bahls (1993) for diatom communities in reference streams from mountain ecoregions.

The **siltation index** is defined as the total percent relative abundance of diatom species belonging to the genera *Navicula*, *Nitzschia* and *Surirella* present in a sample. These genera are comprised largely of highly motile, biraphidean diatoms that are better adapted to existence on unstable, shifting substrates. Values can range from 0 to 100; in mountain reference streams the index ranged from 0.0 to 50.3 (mean 14.5) (Bahls 1993).

The **disturbance index** is simply the percent abundance of the diatom *Achnanthes minutissima.* This cosmopolitan species is an attached form that often pioneers and dominates recently disturbed or scoured sites. While sensitive to organic pollution, *A. minutissima* is quite tolerant of heavy metals and chemical pollutants often associated with mine wastes. The percent abundance of *A. minutissima* has been found to be directly proportional to the time elapsed since the last scouring streamflow or episode of toxic pollution.

The **similarity index,** or percent community similarity (Whittaker 1952) is the sum of the lower of the two percent relative abundance values for all diatom taxa that are in common between two samples. It may be used to gauge the relative amount of impairment or recovery that occurs between adjacent mainstem study sites.

Bioassessment

The two bioassessment protocols (Protocols I and II) utilizing diatom metrics were proposed by Bahls (1993) to assess **biological integrity** and aquatic life impairment in Montana streams. Protocol I compares Shannon diversity index, pollution index, and siltation index values from a study site to criteria developed from least-impaired reference streams located in the same physiographic province, or "ecoregion. Criteria for mountain streams were developed with data from 21 reference streams in the Northern Rockies, Middle Rockies, and the Montana Valley and Foothill Prairies ecoregions (Bahls et al. 1992). Protocol I was applied to Clark Fork Basin diatom data from 1991 through 1998 (Weber 1993, 1995, 1996, 1997, 1998 and 1999). An updated version of this protocol utilizing additional metrics was applied to the diatom data in 1999 and 2000, and will again be used with the 2001 data, according to the criteria listed in Table 5. These modified criteria are as of yet unpublished (Dr. Loren Bahls, personal communication). Each of the metrics generated for a study site is given an individual rating and assigned a score based on the criteria in Table 5. The lowest rating or score determines the overall biological integrity, level of impairment and use support rating for the aquatic community at that station. As with the original protocol, the criteria should only be used with data collected during the summer months.

Protocol II, which compares diatom metrics values from a study site to values from a local upstream or sidestream reference site sampled at the same time, was applied to Clark Fork Basin diatom data from 1993 through 1996 (Weber 1995, 1996, 1997 and 1998). A component of Protocol II is the **similarity index** or percent community similarity, which is described under diatom metrics, above. Comparisons of study and reference sites located in different drainages often resulted in low scores due to very dissimilar diatom floras. Because the lowest score established the overall biological integrity and impairment rating (as with Protocol I), ratings were often driven downward by the use of the similarity index in this fashion. It is likely that differences between the diatom floras at Clark Fork mainstem stations and tributary reference streams (such as Rock Creek or the Blackfoot River) is a natural condition, and not related to water quality degradation (Dr. Loren Bahls, personal communication). For this reason Protocol II is no longer used to assess Clark Fork data. Similarity Index values will be used to assess change between adjacent sites on Silver Bow Creek and the Clark Fork mainstem.

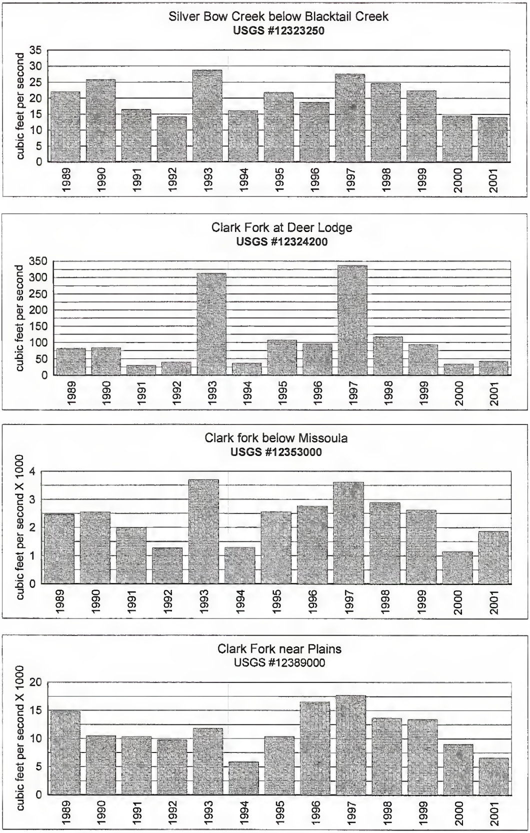
RESULTS AND DISCUSSION

Monthly mean streamflows for August of the twelve-year period 1989-2001 at selected USGS gaging stations in the Clark Fork Basin are presented in Table 2 and Figure 2. Streamflows at the Silver Bow Creek and Clark Fork near Plains gages during August of 2001 were lower than in 2000, and at or near low values recorded for the previous twelve years. At the Deer Lodge and Missoula gages, August monthly mean flows for 2001 were somewhat higher than in August of 2000, but were still well below the long-term average. The extended drought continued to have an impact on instream flows in the Clark Fork Basin in 2001. However, severe thunderstorms on the afternoon of August 4, 2001 dropped heavy rains on the upper Clark Fork drainage, just as the monitoring effort was getting under way. As sampling was concentrated in the Missoula area that afternoon and the next day, effects of the upstream deluge on streamflows were not evident until the morning of August 6. A significant spike in Clark Fork flows, documented in the USGS flow data from gaging stations above the mouth of the Blackfoot River, was obvious at Turah and Bonita. After the surge passed on the afternoon of August 6, flows dropped rapidly as sampling progressed upstream. Evidence of much higher stream stages over the previous two days was very apparent in the channel all the way to Butte. Water temperature did not exceed 24 degrees Celsius during the afternoon, despite very warm weather. Flows were again conducive to algal growth and ease of sample collection, and most mainstem Clark Fork reaches had very substantial algal standing crops in 2001.

Table 2. August monthly mean streamflows at selected USGS gaging stations in the Clark Fork Basin for the years 1989-2001 (cubic feet per second).

Year	Silver Bow Creek below Blacktail Creek USGS # 12323250	Clark Fork at Deer Lodge USGS # 12324200	Clark Fork below Missoula USGS # 12353000	Clark Fork near Plains USGS # 12389000
1989	22.0	81.7	2464	14750
1990	25.8	84.3	2554	10510
1991	16.4	30.1	1997	10350
1992	14.2	40.1	1280	9738
1993	28.7	312	3696	11770
1994	16.1	36.3	1295	5891
1995	21.8	107	2561	10360
1996	18.7	95.2	2766	16530
1997	27.5	337	3620	17700
1998	24.6	117	2890	13700
1999	22.4	93.4	2625	13420
2000	14.5	34.5	1145	9010
2001	**14.0**	**42.1**	**1865**	**6589**
Mean	20.5	108.5	2366	11563

Figure 2. August monthly mean streamflows at selected USGS gaging stations in the Clark Fork Basin for the thirteen year period 1989-2001.



Non-Diatom Algae

All genera of non-diatom algae identified at each of the Clark Fork and tributary stations during August 2001 are listed by phylum in Appendix A, along with estimated relative abundance and biovolume contribution rankings. Diatom algae (all genera considered collectively) are also included for comparison. are also listed in Appendix A. Numbers of dominant non-diatom genera by phylum as green algae, blue-green algae and "other" (yellow-green, brown and red) algae for 2001 are plotted in Figure 3. The top five non-diatom genera at each of the stations sampled during 2001, as determined by estimated biovolume contribution, and the number of dominant non-diatom genera (those estimated as common or greater in relative abundance) and the dominant phylum are listed in Tables 3 and 4. Diatoms were ranked no lower than fourth in estimated biovolume relative to non-diatom algae, and are listed for comparison.

In 2001, the number of dominant non-diatom algal genera present at the 28 Clark Fork and tributary stations ranged from 4 to 13 (mean 8.6). **Silver Bow Creek at Opportunity (station 2.5)** was the only station with fewer than 5 non-diatom genera present in August 2001 (Table 3; Figure 3).

Green algae (phylum Chlorophyta) were dominant (based on estimated biovolume) at 15 of 28 stations, while blue-green algae (phylum Cyanophyta) were dominant at 8 stations. Green and blue-green algae were co-dominant at five stations in 2001 (Tables 3 and 4; Appendix A).

Non-diatom algae in **Blacktail Creek above Grove Gulch (station SF-1)** were represented by the filamentous Chrysophyte *Vaucheria* and the filamentous greens *Oedogonium* and *Microspora* (Table 3). These taxa generally prefer cool, clean, well-aerated flowing water that is somewhat soft and moderately rich in algal nutrients. The filamentous blue-green alga *Oscillatoria*, a genus with many species that span a broad autecological amplitude, was also relatively important. Diatom algae ranked third in estimated biovolume relative to the non-diatom taxa (Table 3).

The three Silver Bow Creek stations upstream of the Warm Springs Ponds had from four to nine dominant non-diatom taxa in 2001 (Figure 3). All of these stations had large amounts of unstable, coarse granitic sand in the stream channel. The algal flora at **Silver Bow Creek above the Butte Metro Wastewater Treatment Plant (WWTP) (station 00)** was dominated by the colonial green alga *Gloeocystis,* the filamentous green *Cladophora*, and the filamentous blue-greens *Oscillatoria* and *Phormidium* (Table 3). All of these taxa, and particularly the green algae, tolerate or prefer moderate algal nutrient and alkalinity levels. Reclamation activities and channel reconstruction along this reach within the last three or four years, including soil liming and fertilization, are likely still influencing the algal flora. The non-diatom algae at this station had little in common with those present in Blacktail Creek a short distance upstream. **Silver Bow Creek below Lower Area One** (the former Colorado Tailings) **and Butte Metro WWTP (station 01)** was dominated by the filamentous Chrysophyte *Vaucheria* and green algae *Stigeoclonium* and *Gloeocystis*, with diatom algae fourth in relative importance (Table 3). The Butte Metro wastewater discharge typically accounts for much of the streamflow volume in Silver Bow Creek at station 01, and strongly influences the water quality with elevated levels of algal nutrients, dissolved solids and temperature

for a considerable distance downstream of the confluence. Additionally, extensive deposits of mill tailings line the Silver Bow Creek floodplain between stations 01 and 2.5. These historic deposits have contributed elevated levels of dissolved copper, zinc and other heavy metals, as well as toxic sediments, to this reach. Major work under the Superfund Program to reclaim and restore the Silver Bow channel and floodplain between station 00 and Rocker, including the reach containing station 01, was underway during the summer of 2001. Station 01 will likely be re-established in the new channel in 2002. **Silver Bow Creek at Opportunity (station 2.5)** had only four dominant non-diatom taxa in 2001 (Figure 3), and was strongly dominated by the highly pollution-tolerant green algae *Scenedesmus* and *Cosmarium* (Table 3). The number of non-diatom algal taxa present at Blacktail Creek and three upper Silver Bow Creek stations in 2001 decreased from upstream to downstream, with pollution-sensitive forms giving way to pollution-tolerant forms. Silver Bow Creek between station 01 and the Warm Springs Ponds (including station 2.5) remains the most severely impacted stream reach in the study due to extensive mine and mill tailings deposits and anthropogenic wastes.

Silver Bow Creek below Warm Springs Ponds (station 4.5) had ten dominant non-diatom taxa present in August 2001 (Figure 3). The diverse assemblage was dominated by the green algae genera *Oedogonium* and *Cladophora,* both filamentous forms, and the blue-greens *Nostoc*, *Phormidium* and *Chamaesiphon.* While both green and blue-green genera contributed significantly to the total algal biovolume at station 4.5 (Table 3), the blue-greens (Cyanophyta) comprised the dominant phylum at station 04, with seven genera present (Figure 3; Appendix A). This suggests that nitrogen may have been the limiting algal nutrient, as many of the blue-greens can fix atmospheric nitrogen and take advantage of excess phosphorous. Much of the channel was also heavily colonized with rooted macrophytes, giving the impression of a spring creek. It is obvious through comparison with station 2.5 upstream that the water quality in Silver Bow Creek at station 4.5 is greatly improved as a result of the Warm Springs Ponds. All indications are that relatively clean, well-aerated, albeit warm and nutrient-rich, water was discharged from the Warm Springs Ponds. However, while the Pond System effectively removes heavy metals while contributing to the richness (i.e. organic matter, algal nutrients and bicarbonate) of Silver Bow Creek at station 4.5, it appears that the significant volume of cool, high-quality water from the combined Mill and Willow Creeks is also very important.

Mill Creek-Willow Creek Bypass near mouth (station MW2) was re-established in 1999, seven years after the original study station 5 was eliminated due to Superfund remediation and reconstruction activities. The 2001 monitoring was conducted at the same location as in 2000, at a point adjacent to the parking area at the end of the Dept. of Fish, Wildlife and Parks recreation access road south of Warm Springs. This site is about a half mile upstream of the confluence with the Warm Springs Ponds discharge. The carefully contoured stream channel is well armored, and has a good diversity of riffle, run and pool habitats. The dominant green and blue-green algae present at station MW2 were virtually the same as those present downstream at Silver Bow Creek station 4.5, below the Warm Springs Ponds (Table 3). The green algae (Chlorophyta) comprised the dominant phylum at station MW2, possibly indicating more available nitrogen than downstream at Silver Bow Creek. station 4.5.. The red alga *Asterocystis* was also common at MW2 (Appendix A). These taxa indicate good water quality in the Mill-Willow Bypass in August 2001, that appears to

strongly influence the algal assemblage in Silver Bow Cr. downstream of the Warm Springs Ponds.

At **Warm Springs Creek near mouth (station 06),** the non-diatom flora from was similar to those from the Mill-Willow Bypass and Silver Bow Creek below the Warm Springs Ponds (Table 3; Appendix A). The diverse periphyton assemblage was dominated by the blue-greens *Nostoc* and *Oscillatoria,* the green algae *Oedogonium* and *Cladophora*, and the golden alga *Vaucheria*, along with very abundant diatoms. These taxa suggest Warm Springs Creek was contributing moderately rich, high quality water to the upper Clark Fork during August 2001.

The non-diatom algae at the **Clark Fork below Warm Springs Creek (station 07)** had much in common with Silver Bow Creek station 4.5, Warm Springs Creek station 06 and Mill-Willow Bypass station MW2, which come together a very short distance upstream to form the Clark Fork. The filamentous green algae *Cladophora*, *Oedogonium* and *Spirogyra*, and the blue-greens *Nostoc* and *Oscillatoria* made up the bulk of the seven dominant non-diatom taxa present at station 07 (Table 3, Appendix A). These algae again indicate relatively clean, nutrient-rich water at the headwaters of the Clark Fork. A distinct crust of calcium carbonate (marl), most likely related to the lime added at the head of the ponds, was present over much of the substrate.

The **Clark Fork near Dempsey (station 08)** had six dominant non-diatom algal taxa present in August 2001 (Figure 3), half the number found at this site in 2000 (Weber 2001). Stream flow was very low and dropping at station 08, although visual evidence indicated flows had spiked following heavy thunderstorms several days earlier. Extremely heavy growths of the filamentous green algae *Oedogonium* and *Cladophora* covered much of the riffle in a dense, stringy mat, along with numerous colonies of the blue-green alga *Nostoc*. The red alga *Audouinella* was also very common at station 08, the only upper river site where it was other than rare (Table 3; Appendix A). This assemblage suggests rich water of relatively good quality, despite extensive flats of mill tailings (slickens) observed near the stream course. The Clark Fork has very little gradient through this reach and the riffle sampled, although quite shallow, was the only one available for a considerable distance upstream or downstream. The underside of cobbles at station 08 were stained a deep orange-red, possibly due to the presence of iron and manganese compounds.

Seven dominant non-diatom taxa were present at the **Clark Fork at Sager Lane (station 8.5)** (Figure 3), the same number as in 2000 (Weber 2001). Heavy growths of the filamentous green algae *Oedogonium* and *Cladophora* were present, along with the blue-greens *Nostoc* and *Phormidium* (Table 3). The fairly sensitive red alga *Audouinella* was present, but rare. Compared to upstream stations, these relatively subtle changes may suggest a worsening of water quality through this reach. Stream banks above and below station 8.5 are in very poor shape, and efforts have been made to stabilize erosion with mesh and willow slip plantings, with only marginal success. Extensive tailings 'slickens' are present along this reach, and field observations indicate they continue to be undercut by the stream. Flows were very low at the time of sampling, but recently had been much higher.

The **Clark Fork at Deer Lodge (station 09)** had seven dominant non-diatom genera in 2001 (Figure 3), the same as at upstream station 8.5, but nearly twice that seen in 2000 (Weber 2001). Dominant taxa were very similar to those at stations 08 and 8.5, with the green alga *Oedogonium* again comprising the greatest biovolume, followed by *Cladophora* and the blue-green alga *Nostoc*. Diatom algae were ranked only fourth in relative biovolume at all three stations (Table 3). This suggests relatively constant water quality in the upper Clark Fork mainstem.

The **Clark Fork above the Little Blackfoot River (station 10)** was sampled at the same location in 2001 as in 2000, about 150 meters upstream of the Kohrs Bend fishing access parking lot at the head of the first island (the road washout has been repaired). Eight dominant non-diatom taxa were identified in 2001 (Figure 3). The blue-green algae (Cyanophyta), represented principally by *Nostoc*, were dominant at station 10 (Table 3). Of the green algae *Cladophora* was ranked first in relative biovolume, but unlike the previous four mainstem sites, *Oedogonium* was not included in the top five non-diatom algae (Table 3). This shift in the dominant green algae and the dominant algal phylum suggest a change in water quality, although for better or for worse is not readily apparent. The diatom algae, which were ranked third in relative biovolume, may shed some light on this in the next section.

The **Little Blackfoot River near mouth (station 10.2)** had a diverse assemblage of 11 dominant non-diatom algae in 2001 (Figure 3, Appendix A). The top three non-diatom taxa based on biovolume were *Cladophora* (phylum Chlorophyta), *Nostoc* (phylum Cyanophyta) and *Vaucheria* (phylum Chrysophyta) (Table 3). Diatoms were very abundant and ranked third relative to non-diatom algae. The red alga *Audouinella* was common at station 10.2, and along with the diverse algal assemblage suggests relatively high-quality water in August 2001.

The **Clark Fork at Gold Creek bridge (station 11)** had eight dominant non-diatom algae present in 2001 (Figure 3), with a taxa makeup similar to upstream station 10 (Table 3, Appendix A). Blue-green algae (phylum Cyanophyta) were again dominant at station 11, with the colonial form *Nostoc* ranked second, and five other genera considered dominant forms. Several of the blue-green taxa are capable of fixing atmospheric nitrogen, and would have a competitive advantage in nitrogen-limited waters. The phosphorous-rich Phosphoria Formation straddles the Clark Fork valley in this vicinity (Ingman *et al.*1979), which suggests nitrogen indeed may be the limiting algal nutrient in the Clark Fork through the Gold Creek reach. Heavy growths of *Cladophora* were also present at station 11, while *Oedogonium* was entirely absent (Table 3, Appendix A) . Diatoms were less important at station 11, ranking only fourth in estimated biovolume (Table 3).

Flint Creek at New Chicago (station 11.5) had a relatively diverse algal assemblage of 10 dominant non-diatom taxa in 2001(Figure 3). The blue-greens *Nostoc* and *Oscillatoria* and the green alga *Cladophora* dominated the flora along with diatoms, together making up the top four taxa in estimated biovolume (Table 4). The red alga *Audouinella* was also one of the top five non-diatom taxon at station 11.5 in 2001. These taxa suggest at least moderately rich, relatively good water quality in Flint Creek during August of 2001. Heavy use of the stream bottom riparian habitat by

livestock, and the resulting degraded streambank conditions in the vicinity and upstream of station 11.5 are likely sources of elevated nutrients and sediment in Flint Creek.

There were ten dominant non-diatom taxa present in the **Clark Fork at Bearmouth (station 11.7)** in 2001 (Figure 3; Appendix A). The blue-green algae (phylum Cyanophyta) accounted for four of the top five taxa, with the macroscopic colonial genus *Nostoc* ranked first and the microscopic epiphyte *Chamaesiphon* ranked third in biovolume (Table 4). *Cladophora* was the only green alga represented in the top five, and was ranked second in biovolume at station 11.7 (Table 4). *Chamaesiphon* colonizes extensive areas on the surface of the much larger *Cladophora* filaments, creating masses of thousands of closely arranged, short filaments. A close relationship likely exists between *Cladophora* and epiphytic algae, including *Chamaesiphon, Phormidium* and several diatom species that undoubtedly has important implications pertaining to resource availability (i.e. nutrients, sunlight, etc.) for all algae involved. The change over the last year, from a periphyton assemblage dominated by green algae (Weber 2001) to one dominated by blue-green algae suggests a change in the instream nutrient budget, possibly to a nitrogen-limited condition.

Eight dominant non-diatom taxa were present in the **Clark Fork at Bonita (station 12)** (Figure 3), and as at the previous station, the majority of these were blue-green algae (Figure 3). Overall, the makeup and distribution of dominant non-diatom taxa at station 12 was very similar to station 11.7 (Table 4, Appendix A). And as with station 11.7, the blue-green algae became the dominant phylum in 2001, rather than the green algae that dominated in 2000 (Weber 2001). *Nostoc* continued to be the number one rated taxon by biovolume, while *Cladophora* again was rated second (Table 4). It appears that water quality at stations 11.7 and 12 was very similar in August 2001, with the same algal nutrients likely limiting. The water was quite turbid and the flow noticeably higher at Clark Fork station 12 on August 6, 2001, as a result of heavy thunderstorms in the upper reaches two days earlier. Some sloughing of the heavy algal standing crop was evident as clumps and strings of *Cladophora* drifting in the water column.

Rock Creek near Clinton (station 12.5) had a fairly diverse assemblage of eleven non-diatom algae during August of 2001 (Figure 3), that was quite dissimilar to the flora at nearby Clark Fork stations (Table 4). The green algae *Chaetophora* and *Ulothrix* and the blue-greens *Rivularia* and *Tolypothrix,* forms generally found in cold, nutrient-poor flowing water, were in the top five non-diatom taxa ranked by biovolume, after the diatom algae. The absence in 2001, as in 2000, of algal phyla other than the Chlorophyta and Cyanophyta suggests that the biota in Rock Creek may have been under some degree of stress. Rock Creek's cold, clean, well-oxygenated water has typically supported a number of more sensitive genera, including the red alga *Lemanea* and the brown alga *Heribaudiella* (Weber 2001).

The **Clark Fork at Turah (station 13)** had seven dominant non-diatom taxa present in August 2001 (Figure 3), down considerably from the eleven identified last year (Weber 2001). The dominant taxa at station 13 were similar in makeup to those at upstream stations 11.7 and 12 (Table 4) with *Nostoc, Cladophora* and diatoms ranked first through third, respectively. The pollution-tolerant filamentous green *Stigeoclonium* was abundant and ranked fourth in biovolume at station 13, but had not been

in the top five taxon since Silver Bow Creek (Table 4). Rock Creek may have influenced the algal assemblage at station 13 to some degree, as the blue-green *Tolypothrix* appeared as a dominant taxon for the only time on the Clark Fork mainstem (Table 4).

The **Blackfoot River near mouth (station 14)** had ten dominant non-diatom taxa present in August 2001 (Figure 3), down somewhat from the 13 taxa seen in 2000 (Weber 2001). The presence of the blue-green genera *Oscillatoria, Dichothrix* and *Nostoc*, and the pollution-sensitive filamentous green alga *Chaetophora* suggest clean, cold, and somewhat softer water in the Blackfoot River (Table 4). Additional taxa indicative of clean water, including *Heribaudiella*, *Rivularia* and *Mougeotia,* were found in the Blackfoot River in 2001 although they were lower in numbers and biovolume (Appendix A).

The **Clark Fork above Missoula (station 15.5)** had ten dominant non-diatom taxa present during August of 2001 (Figure 3). The flora at station 15.5 was somewhat dissimilar in composition to Clark Fork stations 11.7, 12 and 13 upstream of the Blackfoot River. The pollution-tolerant blue-green *Phormidium* exceeded the more sensitive *Nostoc* in importance, and the filamentous green alga *Oedogonium* appeared once again as a dominant taxon second only to *Cladophora* in biovolume (Table 4). These taxa indicate water rich in algal nutrients but of high quality, likely due to the contributions of Rock Creek and the Blackfoot River.

The **Clark Fork at Shuffields (station 18)** is located downstream of the Missoula Wastewater Treatment Plant (WWTP) discharge. Ten dominant non-diatom taxa were present at station 18, with *Oscillatoria, Cladophora, Cosmarium, Stigeoclonium* and *Phormidium* accounting for much of the non-diatom algal biovolume at station 18. These taxa all tolerate, or even prefer somewhat elevated levels of algal nutrients, particularly nitrogen. The decline at station 18 of less-tolerant taxa found upstream at station 15.5, particularly *Oedogonium* and *Nostoc*, suggests at least a minor impact related to Missoula's wastewater, and possibly to non-point sources of pollution within the Missoula urban corridor.

Seven dominant non-diatom genera were found in the **Bitterroot River near mouth (station 19)** during August of 2001(Figure 3), down from the twelve present last year (Weber 2000). Included are forms preferring somewhat elevated levels of algal nutrients, particularly *Cosmarium, Stigeoclonium*, *Scenedesmus*, and *Phormidium*, as well as the less tolerant forms *Oedogonium* and *Oscillatoria* (Appendix A; Table 4). The pollution-sensitive brown alga *Heribaudiella* was very common and ranked fourth in biovolume (Table 4). The algal taxa present indicate relatively clean water, although algal nutrient levels in the Bitterroot River likely are increasing due to the very extensive forest fires throughout the drainage during the summer of 2000.

At the **Clark Fork at Harper Bridge (station 20)**, downstream of the confluence with the Bitterroot River, ten dominant non-diatom taxa were present in August 2001 (Figure 3). The green algae *Cladophora*, *Stigeoclonium, Cosmarium* and *Closterium*, along with diatoms, were responsible for much of the algal biovolume at station 20, and indicate water relatively rich in algal nutrients (Table 4). However, the brown alga *Heribaudiella* was very common, and suggests very good water quality

at station 20 (Appendix A). Blue-green algae were less important at station 20, with *Phormidium* rated as abundant and *Oscillatoria* very common, but neither placed in the top five non-diatom taxa (Table 4). *Nostoc* was entirely absent from station 20, suggesting nitrogen was not in short supply.

The **Clark Fork at Huson (station 22)** was sampled in 2001 at the same location as in 1999. This site was not sampled in 2000 due to access restrictions dictated by the extreme fire danger. Ten dominant non-diatom taxa were present at station 22, eight of which were in common with upstream station 20 (Appendix A). The green algae *Cladophora*, *Closterium* and *Cosmarium*, and the blue-green *Phormidium* were the top four non-diatom taxa ranked by biovolume at station 22 (Table 4). The red alga *Asterocystis* also ranked in the top five non-diatom taxa, while the green alga *Stigeoclonium* dropped to seventh. (Appendix A; Table 4). As with station 20, the complete absence of *Nostoc* suggests adequate levels of available nitrogen.

The **Clark Fork near Superior (station 24)** had thirteen dominant taxa present in August 2001 (Figure 3), the most of any site in 2001 and up slightly from the eleven observed in 2000 (Weber 2001). *Cladophora* accounted for more of the estimated algal biovolume at station 24 than did the diatoms, while the blue-greens *Oscillatoria, Phormidium, Nostoc* and *Chamaesiphon* made up the rest of the top five genera (Table 4). *Nostoc* had not occurred at Clark Fork stations 20 and 22, after placing in the top five non-diatom taxa at every other mainstem station in 2001 (Tables 3 and 4). Other than *Nostoc*, the alga flora at station 24 was fairly similar to upstream stations 20 and 22 (Table 4). The red alga *Asterocystis* remained very common at station 24, but did not rank in the top five by biovolume (Appendix A). All of these taxa suggest moderately rich, good quality water at station 24, although the slight decline in the relative importance of diatoms may indicate minor impairment. The increased relative importance of *Nostoc* and *Chamaesiphon* may indicate a decrease in available nitrogen in this reach of river. The Missoula WWTP and the Smurfit-Stone Corporation pulp mill are a considerable distance upstream of station 24, and nitrogen from these sources may have been assimilated.

Eight dominant non-diatom algae were present at the **Clark Fork above the Flathead River (station 25)** in 2001 (Figure 3), compared to 13 in 2000 (Weber 2001). Of the top five non-diatom taxa at station 25, only *Cladophora*, *Oscillatoria* and *Chamaesiphon* were in common with station 24 (Table 4). Diatoms again were very abundant and ranked first in biovolume, the blue-green alga *Nostoc* again was absent and the brown alga *Heribaudiella* was common at station 25 (Table 4; Appendix A). While there were fewer dominant taxa present at station 25 in August 2001, those present suggested relatively nutrient-rich, largely unimpaired water quality in the lower Clark Fork.

The **Clark Fork above Thompson Falls Reservoir (station 27)** had ten dominant algal genera present in August of 2001 (Figure 3). The non-diatom algal flora was dominated by green algae, with *Cladophora*, *Cosmarium*, *Pediastrum* and *Scenedesmus* making up four of the top five taxa by biovolume (Table 4). Of the blue-green algae, *Dichothrix* was very common and ranked third in biovolume, while *Phormidium* was common but relatively unimportant. This site is located below the confluence of the Flathead River with the Clark Fork, and because the river is twice the size and significantly different in chemical makeup, any comparisons to upstream sites are questionable.

Diatom Algae

The estimated abundance of diatom algae (all genera considered collectively) relative to non-diatom algal genera at the 28 Clark Fork and tributary stations monitored in 2001 are included in Tables 3 and 4, and in Appendix A. Diatoms are also ranked with non-diatom genera according to their estimated contribution to total periphyton biovolume in each sample (Tables 3 and 4; Appendix A).

Diatoms were ranked at least "very common" at all 28 stations in 2001 (Tables 3 and 4, Appendix A). Diatoms were considered "dominant algae" at all 28 stations monitored in 2001, and were ranked first, second or third in estimated biovolume at 19 of the stations. Diatoms were not ranked below fourth in estimated biovolume at any Clark Fork or tributary station in 2001.

All diatom species identified during the floristic scans and proportional counts are listed alphabetically in Appendix B for the 2001 monitoring, with percent relative abundance (PRA) values for all diatom species tallied. Diatom species identified during the floristic scan but not encountered during the proportional count are tallied as a single valve and included in metrics calculations. In previous years these species were only denoted as "present" with a letter "p". Lange-Bertalot pollution tolerance (PT) group assignments for each diatom species are also listed in Appendix B.

Major diatom species, formerly defined as all taxa that account for 10.0 percent or more of the diatom cells counted at one or more station, but expanded in 2001 to include (generally) the five most numerous taxa at each station, are listed in Table 6 for upper Clark Fork and tributary stations, and Table 7 for middle and lower Clark Fork and tributary stations.

Values for diatom **species richness** (number of species counted) at each station monitored during 2001 are listed in Tables 6 and 7. The total percent relative abundance of diatom taxa in each of the three Lange-Bertalot pollution tolerance groups at each station are listed in Appendix B.

Values for the **Shannon diversity index, pollution index, siltation index and disturbance index** calculated for each station monitored during 2001 are listed in Tables 6 and 7, and are plotted in Figures 5, 6 and 7, respectively.

Similarity Index (percent community similarity) values, calculated for adjacent stations on Silver Bow Creek and the Clark Fork mainstem, are listed in Table 6 and plotted in Figure 4.

Ratings for **biological integrity, overall impairment of aquatic life**, and **beneficial use support** for each of the 28 stations monitored in August 2001, as determined by criteria in Table 5, are listed in Tables 8 and 9.

Diatom Species Richness

With the exception of one Silver Bow Creek station, diatom species richness values at all Clark Fork and tributary stations in 2001 were within the range of 23-51 species established by Bahls et al. (1992) for least-impaired reference streams from mountain ecoregions. Species richness was 29 or less at only two of the 28 stations in 2001, but only one of those stations had fewer than 20 species and was considered to suffer greater than minor impairment (Tables 6 and 7). The lowest diatom species richness value during August 2001 was found in the reach of Silver Bow Creek above the Warm Springs Ponds. **Silver Bow Creek below Lower Area One** (the former Colorado Tailings) **(station 01)** had 17 species, indicating moderate impairment with partial support of aquatic life uses according to criteria in Table 5. **Silver Bow Creek at Opportunity (station 2.5)** had 28 species tallied, indicating minor impairment of aquatic life but full support of aquatic life uses (Table 6). The remaining 26 Clark Fork and tributary stations had species richness values ranging from 34 to 74, with no impairment of aquatic life beneficial uses indicated (Tables 6 and 7).

Diversity Index

The Shannon diversity index fell within or exceeded the range of 2.16-4.50 determined for least-impaired reference streams by Bahls et al. (1992) at 27 of 28 stations monitored in 2001 (Tables 6 and 7, Figure 5).

One station had a diversity index value of 1.00-1.99 that indicates moderate aquatic life impairment (Table 6, Figure 5). The low diversity index value of 1.59 was at **Silver Bow Creek below Lower Area One** (the former Colorado Tailings) **(station 01)**. Two stations had diversity index values of 2.00-2.99 that indicate minor impairment of aquatic life, but full support of aquatic life uses: **Mill-Willow Bypass near mouth (station MW2)** and **Clark Fork at Gold Creek bridge (station 11)** (Table 6, Figure 5).

The remaining 25 stations had Shannon diversity values that exceeded 2.99 (Tables 6 and 7; Figure 5). The highest diversity index value, 4.90, occurred at **Clark Fork above Thompson Falls Reservoir (station 27)**, which is downstream of the confluence of the Flathead River and the Clark Fork. The "coming together" of these large rivers with their very different water character likely contributed to the very high diversity index value at station 27.

Pollution Index

Pollution index values at 25 of 28 Clark Fork Basin stations monitored in 2001 were within the range of 2.45-2.94 determined by Bahls et al. (1992) for least-impaired reference streams. At 23 of the 28 sites monitored in 2001, pollution index values exceeded 2.50 and the sites were considered unimpaired and fully supportive of aquatic life uses (Table 6 and 7, Figure 6).

Severe impairment of aquatic life, with non-support of beneficial aquatic life uses, was indicated by the pollution index value at only one site in August 2001: **Silver Bow Creek below Lower Area One** (the former Colorado Tailings) **(station 01)** (Table 6; Figure 6). The low pollution index value of 1.06 was a direct result of the Butte municipal wastewater discharge.

The pollution index indicated moderate impairment of aquatic life with only partial support of beneficial uses at one site in 2001: **Silver Bow Creek at Opportunity (station 2.5)** (Table 6). Butte's treated wastewater and large deposits of historical mine and mill tailings in the Silver Bow Creek floodplain between Butte and Opportunity are responsible for the value of 1.64 at station 2.5.

Pollution index values at an additional three sites in 2001 indicated minor impairment of aquatic life, with full support of beneficial uses (Table 6; Figure 6). These included **Silver Bow Creek above the Butte WWTP (station 00), Clark Fork at Sager Lane (station 8.5)** and **Clark Fork at Deer Lodge (station 09)**, all in the upper Clark Fork basin.

Siltation Index

The siltation index has the opposite response to degraded conditions that is seen with the diversity index and pollution index: that is, the higher the value the worse the siltation problem. Siltation index values at 26 of the 28 sites monitored in 2001 were within the range of 0.0-50.3 determined by Bahls et al. (1992) for least impaired reference streams (Figure 7). None of the 28 stations monitored in 2001 had siltation index values greater than 59.9, that would indicate severe impairment of aquatic life with non-support of beneficial uses (Table 6, Figure 7).

Five of 28 stations had siltation index values that indicated moderate impairment, with only partial support of beneficial uses, according to criteria in Table 5 (Tables 6 and 7). These include: in the Silver Bow Creek drainage, **Silver Bow Creek at Opportunity (station 2.5)**; in the upper Clark Fork reach, **Clark Fork at Sager Lane (station 8.5)**; in the middle Clark Fork reach, **Flint Creek at New Chicago (station 11.5)**, and in the lower Clark Fork reach, **Bitterroot River near mouth (station 19)** and **Clark Fork at Harper Bridge (station 20)**.

Of the 28 stations monitored in 2001, 17 had siltation index values indicating minor impairment of aquatic life, but fully supporting beneficial aquatic life uses (Tables 6 and 7). These stations are located in the upper, middle and lower Clark Fork reaches, as well as on tributary streams. These include: in the Silver Bow Creek drainage, **Silver Bow Creek above Butte WWTP (station 00), Silver Bow Creek below Lower Area One** (the former Colorado Tailings) **(station 01), Silver Bow Creek below Warm Springs Creek (station 4.5)** and **Warm Springs Creek near mouth (station 06)**; in the upper Clark Fork reach, **Clark Fork below Warm Springs Creek (station 07), Clark Fork near Dempsey (station 08), Clark Fork at Deer Lodge (station 09)**, and **Clark Fork above Little Blackfoot River (station 10)**; in the middle Clark Fork reach, **Clark Fork at Gold Creek bridge (station 11), Clark Fork at Bearmouth (station 11.7), Clark Fork at Bonita (station 12), Clark Fork at Turah (station 13), Clark Fork above Missoula (station 15.5)** and **Clark Fork at**

Shuffields (station 18); and in the lower Clark Fork reach, **Clark Fork at Huson (station 22), Clark Fork near Superior (station 24)** and **Clark Fork above the Flathead River (station 25).**

Only the six remaining stations were rated as unimpaired, and fully supported of aquatic life uses from the standpoint of siltation. Of the six, five were tributaries and three were upstream of the Blackfoot River (Tables 6 and 7). These include: **Blacktail Creek above Grove Gulch (station SF-1), Mill-Willow Bypass near mouth (station MW2), Little Blackfoot River near mouth (station 10.2), Rock Creek near Clinton (station 12.5), Blackfoot River near mouth (station 14)** and **Clark Fork above Thompson Falls Reservoir (station 27).**

Individual Site Assessments

Each of the 28 mainstem and tributary stations sampled in August of 2001 are rated for **biological integrity** and **overall impairment of aquatic life**, as well as to the degree of **beneficial use support** in Tables 8 and 9, according to the seven criteria listed in Table 5. Assessments of Clark Fork Basin monitoring sites in 2001 follow the same protocol used for the last two years (Weber 2000 and 2001) and are essentially the same as those done for the eight years of monitoring prior to 1999 under bioassessment Protocol I (Weber 1993, 1995, 1996, 1997, 1998 and 1999). A minimum score that corresponds to criteria in the last column of Table 5 is included with the ratings in Tables 8 and 9. Similarity index (percent community similarity) values of the diatom floras at adjacent mainstem Silver Bow Creek and Clark Fork sites are plotted in Figure 4 and listed in Tables 6 and 7, and are used to assess change between stations where possible. Temporal trends in the pollution index at each station over the last twelve years are plotted in Figures 8-35.

Blacktail Creek above Grove Gulch (station SF-1)

Based on metrics in Table 6 and the assessment criteria in Table 5, biological integrity in Blacktail Creek at **station SF-1** in August of 2001 was rated good, with minor impairment of aquatic life indicated due to a slightly elevated percent relative abundance (PRA) value for the dominant diatom species. The diatom metrics indicate Blacktail Creek fully supports beneficial aquatic life uses.

The major diatom taxa, *Achnanthes biasolettiana* and *Fragilaria construens,* indicate cool, well-oxygenated, slightly alkaline water with moderately low nutrient levels at **station SF-1** in August 2001. The stream bottom of Blacktail Creek is composed primarily of shifting granitic sands, and except for a section of large cobbles and boulders placed at the mouth of a culvert under the Interstate highway, stable substrates are rare. This jumble is the only habitat available for macroinvertebrate sample collection, and a significant portion of the periphyton sample was collected from these rocks as well. The diatom algae identified from Blacktail Creek may reflect the creek's potential if adequate benthic substrate was available.

Pollution index values for Blacktail Creek at **station SF-1** for August of the years 1993-2001 are plotted in Figure 8. The 2001 value was the highest yet determined over the period of record, and continues a trend for improving pollution index values in Blacktail Creek following the low value determined in 1997. The data suggests an improvement in water quality over the last four years.

Silver Bow Creek above Butte WWTP (station 00)

Biological integrity at Silver Bow Creek **station 00** was rated good, with only minor impairment of aquatic life due to a depressed pollution index value and a slightly elevated siltation index value (Table 6). Beneficial uses of aquatic life were fully supported in August 2001, according to criteria in Table 5.

Of the major diatom taxa present at Silver Bow Creek **station 00**, *Epithemia sorex* and *Fragilaria construens* are cosmopolitan forms indicative of relatively good water quality that do well in flowing water and are tolerant of some nutrient enrichment. *Gomphonema parvulum*, *Nitzschia palea* and *Synedra* ulna, on the other hand, generally prefer elevated levels of inorganic and organically bound nitrogen. Silver Bow Creek was relocated into a newly constructed stream channel skirting the former Colorado Tailings site in 1998. Fertilizer applied to promote growth of ground cover and streambank vegetation may continue be the source of elevated nitrogen in this reach. In August 2001 the channel appeared to be developing many attributes of a natural stream course. Riparian vegetation was established, and stream banks were relatively stable. A considerable amount of granitic sand was present on the stream bottom, which supported well established beds of rooted macrophytes, especially *Ranunculus sp*. This is likely the natural condition for Silver Bow Creek.

The percent community similarity between diatom floras from Silver Bow Creek **station 00** and Blacktail Creek **station SF-1** upstream, indicated somewhat dissimilar floras and moderately different water quality between these stations in 2001 (Tables 5 and 6, Figure 4).

Pollution index values for Silver Bow Creek **station 00** over the period 1989-2001 are plotted in Figure 9. The 2001 pollution index value was little changed from 2000, and was comparable to 1998, the first year the reclaimed channel was monitored. Water quality and biological integrity at **station 00** appear to have improved significantly in response to Superfund remediation efforts, particularly compared to the very poor period of 1995-1997 (Figure 9).

Silver Bow Creek below Lower Area One (the former Colorado Tailings) **(station 01)**

Biological integrity was rated as poor, with severe impairment of aquatic life at Silver Bow Creek **station 01** during 2001 (Table 8). Beneficial uses of aquatic life were not supported at station 01, as indicated by a very low pollution index value (Table 6, Figures 6). Shannon diversity was also moderately depressed at **station 01** (Figure 5).

The major diatom species at **station 01** included *Gomphonema parvulum*, *Navicula seminulum* and *Nitzschia palea*, all pollution-tolerant (PT group 1) taxa that when highly dominant are indicative of severely degraded water quality. The severe impairment of aquatic life indicated at Silver Bow Creek **station 01** is primarily the result of excessive biogenic waste loading from the Butte Metro Wastewater Treatment Plant. It is likely that toxic metals concentrations have decreased significantly in this reach due to ongoing Superfund remediation efforts, which have established Silver Bow Creek in a new channel following removal of toxic mill tailings from the floodplain.

The percent community similarity between Silver Bow Creek **station 01** and upstream **station 00** for 2001 indicated somewhat dissimilar diatom floras, with a moderate change between the stations (Tables 5 and 6, Figure 4).

Pollution index values at Silver Bow Creek **station 01** over the thirteen year period of record are the lowest of any station in the Clark Fork Basin (Figure 10). The August 2001 value for pollution index was the poorest yet measured, down considerably from the previous year and well below the mean value for **station 01** (Figure 36). The weak trend for improvement seen since 1998 has apparently reversed, and water quality continues to be very poor in Silver Bow Creek below Lower Area One. It should be noted that major tailings removal efforts were underway at Rocker during August 2001, although the stream channel had not been disturbed in the reach sampled. A new channel will be in place in 2002, and the monitoring location will require reevaluation at that time.

Silver Bow Creek at Opportunity (station 2.5)

The second poorest pollution index value, and the worst siltation index value determined for any station during August of 2001 at Silver Bow Creek **station 2.5** (Table 6, Figures 6 and 7), resulted in a biological integrity rating of fair with moderate impairment of aquatic life indicated (Table 8). However, this was an improvement over the poor rating returned by the same metrics for **station 2.5** in 2000 (Weber 2001). The diversity index indicated no impairment at **station 2.5**, according to the criteria in Table 5 (Table 6, Figure 5), which was also a major improvement over the year 2000.

Major diatom taxa at **station 2.5** included *Navicula minima, Gomphonema parvulum* and *Nitzschia palea* (Table 6). All three species belong to pollution tolerance (PT) group 1, and are highly tolerant of organically bound nutrients associated with biogenic wastes, and low oxygen concentrations.

The similarity index value between Silver Bow Creek **station 01** and **station 2.5** indicated somewhat dissimilar floras in 2001, with moderate change between the sites. (Table 6, Figure 4).

Pollution index values determined for **station 2.5** since 1989 are plotted in Figure 11. The pollution index for 2001 rebounded from the low value seen in 2000, possibly reversing a three year downward trend at **station 2.5** that followed a relatively high value in 1997 (Figure 11). The 2001 pollution index value for **station 2.5** was near the mean value for the period of record (Figure 36).

Mill-Willow Bypass near mouth (station MW2)

The station on the Mill-Willow Bypass was rated as having good biological integrity, with minor aquatic life impairment, and fully supported beneficial aquatic life uses in 2001 (Table 8). The siltation index value at **station MW2** was the lowest determined for any site in 2001(Figure 7).

Major diatom species at **station MW2** indicated slightly alkaline water with moderate levels of algal nutrients. *Cocconeis pediculus* was undoubtedly an epiphyte on the heavy growths of *Cladophora.*

Previous monitoring of the Mill-Willow Bypass from 1989 to 1992 was conducted in the original stream channel, which contained significant historic deposits of mill tailings. Following the removal of tailings and extensive channel reconstruction work, **station MW2** was established as part of the EPA and ARCO Superfund monitoring program, and was added to this program in 1999. Pollution index values from the years 1989-1992 suggest dramatic improvement in water quality through this period (Figure 12). The 1999-2001 pollution index values were determined from diatom data collected in the new channel. The 2001 value was the highest yet determined, and exceeds the mean for the period of record, indicating improving water quality at **station MW2** (Figure 37).

Silver Bow Creek below Warm Springs Ponds (station 4.5)

The Warm Springs Ponds serve to remove dissolved and sediment-born heavy metals from upper Silver Bow Creek through the process of lime addition and sedimentation. Biological integrity at Silver Bow Creek **station 4.5**, below the Warm Springs Ponds, was rated as good during August of 2001, with only minor impairment of aquatic life impairment indicated due only to an elevated siltation index value (Tables 6 and 8). Beneficial aquatic life uses were fully supported. The reason for the somewhat elevated siltation index at **station 4.5** is not readily apparent, but may be related to inadequate flushing flows over the last two or three years.

Major diatom species at **station 4.5** included *Cocconeis pediculus, Epithemia sorex* and *Navicula cryptotenella*, all fairly sensitive forms that prefer somewhat alkaline, nutrient-rich water.

Percent community similarity between **station 4.5** and **station 2.5** upstream of the Warm Springs Ponds was extremely low during 2001, indicating a major change in the diatom flora downstream of the treatment ponds (Table 6, Figure 4). Based on the other diatom metrics, it is obvious that water quality at **station 4.5** is much improved over station 2.5, and that the Warm Springs Ponds system is responsible for these improvements. It should be noted that the Mill-Willow Bypass enters the Warm Springs Ponds discharge (Silver Bow Creek) upstream of **station 4.5**, and certainly influences the water quality and the periphyton composition at Silver Bow Creek **station 4.5.**

Pollution index values for **station 4.5** for the period 1989-2001 are plotted in Figure 13. The 2001 value was slightly higher than the values determined in 1999 and 2000, and received an unimpaired rating. A fairly significant trend for improvement in the pollution index seen in 1998 and 1999

appears to have leveled off. The low value seen in 1997 likely was the result of higher streamflows during August of that year that may have reduced the pond system's treatment efficiency, causing increased sediment and/or heavy metals impacts at station 4.5 (Weber 1999). These impacts were not apparent during the last three years, when streamflows were considerably lower.

Warm Springs Creek near mouth (station 06)

Biological integrity at Warm Springs Creek **station 06** during August of 2001 was rated good, with only minor impairment of aquatic life indicated due to a slightly elevated siltation index value (Table 6). Diversity and pollution index values at **station 06** during 2001 indicated the biota was unimpaired, and aquatic life beneficial uses were fully supported (Tables 6 and 8).

The major diatom taxa at **station 06** in August 1999 are pollution-intolerant forms that prefer cool, well-oxygenated water with moderate levels of algal nutrients. *Epithemia sorex* and *Nitzschia dissipata* were the dominant taxa (Table 6).

Pollution index values at Warm Springs Creek **station 06** for the years 1989-2001 are plotted in Figure 14. The 2001 value was slightly higher than in 2000, and was slightly higher than the mean value for the period of record (Figure 37).

Clark Fork reach 1 (CFR1)

Five upper Clark Fork stations comprised CFR1 in 2001: **Clark Fork below Warm Springs Creek (station 07), Clark Fork near Dempsey (station 08), Clark Fork at Sager Lane (station 8.5) Clark Fork at Deer Lodge (station 09)** and **Clark Fork above the Little Blackfoot River (station 10).**

Biological integrity was rated as good, with minor impairment of aquatic life at **station 07, station 08** and **station 10** due to slightly elevated siltation index values, and at **station 09** due to slightly depressed pollution index value as well as an elevated siltation index value (Tables 6, Figures 6 and 7). At **station 8.5**, biological integrity was rated as fair in August 2001, with moderate impairment of aquatic life due to a moderately elevated siltation index value (Table 6, Figure 7). Beneficial aquatic life uses were only partially supported at **station 8.5**, but were fully supported at the other four stations in reach **CFR1** (Table 8).

The similarity index value between **station 07** and upstream station 4.5 indicated somewhat similar diatom floras, with only minor change between the sites (Table 6, Figure 4). **Station 07** and **station 08**, and **station 08** and **station 8.5** also had diatom floras that were somewhat similar with only minor change between them. Diatom floras were very similar between **station 8.5** and **station 09**, with no change between the sites, while **station 09** and **station 10** had somewhat dissimilar diatom floras with moderate change indicated between them (Table 6, Figure 4). The similarity index values

suggest that considerable change occurs in the composition of the diatom flora, particularly at the lower end of **CFR1**.

Stations in **CFR1** had at least three of the diatom species *Cocconeis pediculus, Cocconeis placentula, Cymbella microcephala, Epithemia sorex* or *Navicula cryptotenella* present as dominant taxa (Table 6). These are cosmopolitan taxa that prefer slightly alkaline, moderately nutrient-rich water. Where strongly dominant (as at **station 10**), *Epithemia sorex* may be an indicator of nitrogen-limited conditions, as *E. sorex* is known to harbor endosymbiotic nitrogen-fixing blue-green algae (Cyanobacteria) within its cell walls. *Achnanthes minutissima* was a dominant taxon at **station 8.5** and **station 09**, possibly indicating less stable substrates and greater environmental stress on the diatom community at these stations.

Pollution index values for the period of record at each of the **CFR1** stations are plotted in Figures 15-19. Values during August 2001for all five stations in **CFR1** were slightly higher than in 2000, and exceeded 2.50 at all sites except **station 8.5** and **station 09**. The pollution index in 2001 at each of the five stations in **CFR1,** and as a mean for the reach, exceeded the mean values for the period of record (Figures 36 and 38). This suggests a slight general improvement in water quality in the upper Clark Fork over time

Little Blackfoot River near mouth (station 10.2)

Biological integrity at **station 10.2** on the Little Blackfoot River in August 2001 was rated as good, with minor aquatic life impairment due only to an elevated PRA of the dominant diatom species (Table 6). Beneficial aquatic life uses were fully supported (Table 8). Diversity index, pollution index and siltation index values all indicated unimpaired biota with excellent biological integrity at **station 10.2** in August 2001 (Table 6).

The four most dominant diatom taxa at **station 10.2** in August 2001 are listed in Table 6. All of these taxa prefer slightly alkaline, moderately nutrient-rich, well-oxygenated flowing water. *Cocconeis pediculus* and *C. placentula* are epiphytic forms that likely occurred on abundant filamentous algae.

Pollution index values at Little Blackfoot River **station 10.2** for the period 1993-2001 are plotted in Figure 20. Values have fluctuated slightly over the nine years **station 10.2** has been monitored, falling slightly into minor impairment range on four of the years, but increasing well into the unimpaired range the other five years. The 2001 pollution index value at **station 10.2** increased over the 2000 value, and both years values were well above 2.50, indicating good water quality (Figure 20). The 2001 pollution index value at **station 10.2** exceeded the mean value for the period of record (Figure 37). The relatively high-quality water from the Little Blackfoot River continues to be an important contribution to the Clark Fork.

Flint Creek at New Chicago (station 11.5)

Biological integrity at **station 11.5** was rated as fair during August 2001, with moderate impairment of aquatic life due to an elevated siltation index value (Table 7). Beneficial aquatic life uses were only partially supported at **station 11.5** (Table 9). However, the diversity index and pollution index values were both relatively high and indicated unimpaired aquatic life at **station 11.5** in August 2001 (Table 7).

Navicula cryptotenella, a pollution tolerance (PT) group 2 taxon, was the only diatom species that accounted for more than 10.0 percent of the total cells counted at Flint Creek **station 11.5** in 2001. The top five diatom taxa at **station 11.5**, which accounted for less than 50 percent total PRA, are relatively intolerant to moderately tolerant of pollution and sediment, preferring moderately rich, well oxygenated flowing water. All diatom taxa identified at are listed in Appendix B.

Flint Creek has serious problems related to agriculture and poor streambank conditions that contribute to nutrient enrichment and sediment problems in its lower reaches. The pollution index at **station 11.5** in 2001 was little changed from 2000, and was slightly greater than the mean value for the period of record (Figures 22 and 37).

Clark Fork reach 2 (CFR2)

The four stations that comprise **CFR2** include **Clark Fork at Gold Creek Bridge (station 11), Clark Fork at Bearmouth (station 11.7), Clark Fork at Bonita (station 12),** and **Clark Fork at Turah (station 13)**. Biological integrity was rated as fair at **station 11** in August 2001, due to the moderately high PRA value of the dominant diatom species, while the other principal metrics (diversity, pollution and siltation indexes) indicated at least good biological integrity (Table 6). Biological integrity at **station 11.7, station 12** and **station 13** was rated as good, with only minor impairment of aquatic life due to slightly elevated siltation index values (Tables 6- 9, Figure 7). By comparison, diversity index and pollution index values indicated unimpaired aquatic life at three lower stations in **CFR2** (Table 7). Beneficial aquatic life uses were fully supported at all **CFR2** stations except **station 11**, where beneficial uses were only partial supported.

The diatom floras at adjacent stations in **CFR2** in August 2001 were very similar to one another, with similarity index values ranging from just shy of 65 percent to over 67 percent, and no significant change indicated between the stations (Tables 5 and 7, Figure 4).

Epithemia sorex was the dominant diatom taxon at **station 11, station 11.7, station 12** and **station 13** in August 2001 (Tables 6 and 7). *E. sorex* has a competitive advantage in waters that are nitrogen-limited (in this case due to naturally high levels of available phosphorus) because of endosymbiotic nitrogen-fixing blue-green algae (Cyanobacteria) harbored within its frustule. The relative abundance of *E. sorex* exceeded 50 percent at **station 11**, but remained less than 35 percent at the other stations in **CFR2** (Tables 6 and 7). *Navicula cryptotenella* was a dominant species at

all of the **CFR2** stations, as it was at most upper Clark Fork mainstem and tributary stations in 2001 (Tables 6 and 7).

Pollution index values at **stations 11, 11.7, 12 and 13** for the period of record are plotted in Figures 21, 23, 24 and 26, respectively. At all stations except **station 12,** the pollution index value in 2001 was greater than the 2000 value. The increase was relatively slight at **station 11** but more significant at **stations 11.7** and **13**, compared to relatively low 2000 values at these sites. Despite the decrease in pollution index at **station 12** in 2001, the second year in a row it has shown a decline, the value remained above 2.5 (Figure 24). Of the four stations in **CFR2**, only **station 12** had a pollution index value that was less than the mean value for the period of record (Figure 36). The mean pollution index value for the entire reach **CFR2** in August 2001 was right at the mean value for the period of record (figure 38).

Rock Creek near Clinton (station 12.5)

Biological integrity at Rock Creek **station 12.5** in August 2001 was rated excellent with unimpaired aquatic life (Table 7). Beneficial aquatic life uses in Rock Creek were fully supported in 2001. This is a major improvement over the fair biological integrity rating received by this station in 2000, due to an elevated siltation index value (Weber 2001).

Dominant diatom species at Rock Creek **station 12.5** in 2001 included *Fragilaria construens*, *Cymbella silesiaca* and *Epithemia sorex* (Table 7), all forms preferring cool, well-oxygenated, circumneutral water with moderate nutrient levels.

Pollution index values for **station 12.5** over the nine years of record are consistently well over 2.50, reflecting the dependably high water quality in Rock Creek (Figure 25). The 2001 pollution index value for **station 12.5** was slightly greater than the mean value for the period of record at (Figure 37).

Blackfoot River at USGS Station near mouth (station 14)

The Blackfoot River **station 14** was rated as having unimpaired aquatic life with excellent biological integrity in August 2001, based on the diatom metrics in Table 7 and criteria in Table 5. Beneficial aquatic life uses were fully supported.

Major diatom species at **station 14** included *Cymbella affinis, Cymbella turgidula, Epithemia sorex* and *Achnanthes minutissima* (Table 7). *A. minutissima* prefers cold, well-oxygenated water, and often is a colonizing species following a spate or physical disturbance, while *C. affinis* and *C. turgidula* are closely related species commonly found in moderately rich, slightly alkaline waters, particularly medium to large-sized rivers. All of these taxa belong to pollution tolerance group 3 (Table 7).

Pollution index values at Blackfoot River **station 14** for the twelve years 1989-2000 were very stable and well above 2.5 (Figure 27), indicating consistently high-quality, unpolluted water in this major tributary to the Clark Fork. The pollution index value at **station 14** during August 2000 was slightly lower than the very high value recorded in 1999, as well as the mean value for the period of record (Figure 38).

Clark Fork reach 3 (CFR3)

Two stations, the **Clark Fork above Missoula (station 15.5)**, and the **Clark Fork at Shuffields (station 18)** make up reach CFR3. In August 2001, both **station 15.5** and **station 18** were rated as having good biological integrity with minor impairment of aquatic life due to elevated siltation index values (Table 7, Figure 7). Based on this rating, beneficial aquatic life uses at both **station 15.5** and **station 18** were still fully supported in August 2001. All of the other principal metrics for both of these stations indicated excellent biological integrity and unimpaired aquatic life in 2001 (Table 7).

The similarity index value between **station 15.5** and upstream Clark Fork **station 13** was about 63 percent for 2001, indicating very similar diatom floras in the Clark Fork above and below the Blackfoot River (Tables 5 and 7) . **Station 15.5** and **station 18** had a similarity index of over 71 percent during August 2001, again indicating very similar diatom floras and essentially no change between the stations (Tables 5 and 7). Dominant diatom species worth noting at both **station 15.5** and **station 18** were *Epithemia sorex* and *Navicula capitatoradiata*, both of which prefer moderately rich, slightly alkaline water, and are tolerant of moderate levels of dissolved solids. These stations bracket the "urban" reach of the Clark Fork that flows through the city of Missoula and receives the Missoula WWTP discharge, factors that undoubtedly have an influence on water quality.

Pollution index values for **station 15.5** above Missoula have been relatively constant and consistently high over the thirteen-year period from 1989 to 2001, although a slight decline is evident since 1998 (Figure 28). These values suggest unimpaired water quality in the Clark Fork just below the Blackfoot River and Milltown Dam. At **station 18,** pollution index values were slightly more variable over the same period but generally exceeded 2.5, although a decline over the last two years is also evident following the very high 1999 value (Figure 29). The pollution index values also indicate consistently unimpaired water quality at **station 18** from the standpoint of organic pollution. The August 2001 pollution index values at both **station 15.5** and **station 18** were notably less than the mean value for the period of record (Figure 36). The pollution index value for reach **CFR3** in August 2001 was less than the mean value over the period of record (Figure 38), suggesting a slight worsening of water quality in the reach.

Bitterroot River near mouth (station 19)

Bitterroot River **station 19** was rated as having only fair biological integrity with moderately impaired aquatic life during August of 2001 due to an elevated siltation index value (Table 7) based

on the criteria in Table 5. The diversity index and pollution index values for **station 19** indicated unimpaired aquatic life during August 2001 (Table 7). The pollution index in 2001 continued a decline from the very high value recorded in 1999 (Figure 30), but exceeded the mean value for the period of record (Figure 37).

Dominant diatom species at **station 19** in August 2001 included *Navicula capitatoradiata, Gomphonema pumilum* and *Achnanthes minutissima* (Table 7). These taxa prefer moderately rich, well-oxygenated water. The elevated siltation index value for **station 19** in 2001 is likely an aftermath of the extreme forest fires in 2000, which devastated many tributary watersheds and the Bitterroot River headwaters. Elevated levels of sediment and nutrients will probably impact the water quality in the Bitterroot River and the Clark Fork for some time.

Clark Fork reach 4 (CFR4)

The **Clark Fork at Harper Bridge (station 20)**, and the **Clark Fork at Huson (station 22)** make up reach **CFR4. Station 20** was rated as having only fair biological integrity in 2001 with moderate impairment of aquatic life due to an elevated siltation index value (Tables 5 and 7). Beneficial aquatic uses were only partially supported as **station 20** during August 2001. **Station 22** was rated as having good biological integrity in 2001 with only minor impairment of aquatic life, again due to an elevated siltation index value (Tables 5 and 7). Both **station 20** and **station 22** would be considered unimpaired based on the other principal diatom metrics for those sites (Table 7).

Dominant diatom taxa in reach **CFR4** included *Navicula capitatoradiata, Cymbella affinis,* and *Cocconeis placentula* (Table 7). These species are common in the summer in larger streams having moderately nutrient-rich, circumneutral water. The similarity index between **station 20** and **station 22** exceeded 73 percent in 2001, indicating very similar diatom floras between sites in **CFR4** (Tables 5 and 7, Figure 4).

Pollution index values at Harper Bridge **station 20** and Huson **station 22** over the period 1989-2001 have been above 2.5, although the 2001 values were the lowest determined over the period of record (Figures 31 and 32). Both stations have seen a sharp decline in pollution index since the record high values determined in 1999, and although **station 22** was not sampled in 2000, the trend appears very similar (Figures 31 and 32). The pollution index values for **station 20, station 22** and reach **CFR4** in 2001 are less than the long-term mean values for each (Figures 36 and 38), possibly indicating worsening water quality in this reach.

Clark Fork reach 5 (CFR5)

The **Clark Fork near Superior (station 24)**, and **Clark fork above the Flathead River (station 25)** comprise reach **CFR5**. Biological integrity was rated as good with minor impairment of aquatic life at both **station 24** and **station 25** during August 2001 (Tables 5 and 7). Beneficial aquatic life

uses were fully met at both stations (Table 9). Very slightly elevated siltation index values were responsible for the minor impairment rating at both **station 24** and **station 25**, although the other principal metrics indicated unimpaired biota at both stations.

Community similarity between **station 24** and **station 25** was over 63 percent during August 2001, indicating very similar floras and essentially no change between these stations (Tables 5 and 7, Figure 4). Major diatom species at both stations included *Cocconeis placentula* and *Navicula capitatoradiata.*

Pollution index values at Clark Fork **station 24** and **station 25** have remained quite high over the period 1989-2001, but have declined over the last two years from the 1999 values, which are the highest for the period of record in (Figures 33 and 34). Pollution index values for **station 24, station 25** and **CFR5** during August 2001 were less than the long-term means for the reach over the period of record (Figures 36 and 38). This suggests a possible recent decline in water quality in reach **CFR5.**

Clark Fork above Thompson Falls Reservoir (station 27)

Biological integrity at Clark Fork **station 27**, above Thompson Falls Reservoir, was rated as excellent with no aquatic life impairment during August 2001 (Tables 7 and 9), and beneficial aquatic life uses were fully met. The pollution index value at **station 27** over the period 1989-2001 has exceeded 2.5 with the exception of two years, 1994 and 2000, and increased to well above that in 2001 (Figure 35). The 2001 pollution index value equaled the mean for the period of record (Figure 36). The diatom flora and metrics indicate continued unpolluted conditions in this very large river.

<u>Longitudinal Trend Assessments</u>

Pollution index values for August 2001, and long-term mean values for August of 1989-2001 (fewer years for several stations) at 21 mainstem stations on Blacktail Creek, Silver Bow Creek and the Clark Fork mainstem, are plotted in Figure 36. Pollution index values for selected tributary streams to the Clark Fork during August 2001, and mean values for the period of record for each station are plotted in Figure 37. Mean pollution index values for Silver Bow Creek and Clark Fork reaches during August 2001, and for the period of record for each reach are plotted in Figure 38. Stations or reaches with pollution index values that exceeded the long term mean had somewhat improved water quality during August 2001, while those with values less than the mean likely saw a worsening of water quality.

At Blacktail Creek **station SF-1** in Silver Bow Creek headwaters, and at Silver Bow Creek **station 00** above the Butte WWTP, the pollution index value in 2001 exceeded the long-term mean value (Figure 36). At Silver Bow Creek **station 01** below the Colorado Tailings, the pollution index value

in August 2001 was substantially less than the thirteen-year mean, while at Silver Bow Creek **station 2.5** at Opportunity, the 2001 value was very nearly equal to long-term mean. Silver Bow Creek **station 4.5** below the Warm Springs Ponds had a pollution index value in 2001 that was much greater than the long-term mean value (Figure 36). In the Silver Bow Creek (SBC) reach comprised by the three stations upstream of the Warm Springs Ponds, the mean pollution index for August 2001 was essentially equal to the mean for the period of record (Figure 38).

For the five stations within Clark Fork reach 1 (**CFR1**), **station 07** below Warm Springs Creek, **station 08** near Dempsey, **station 09** at Deer Lodge and **station 10** above the Little Blackfoot River had pollution index values in 2001 that were slightly to moderately greater than the mean value for the period of record, while **station 8.5** at Sager Lane had a value during August 2001 that was nearly equal to the long-term mean (Figure 36). The mean pollution index value for **CFR1** during August 2001 was somewhat greater than the long-term average for the reach (Figure 38).

In Clark Fork reach 2 (**CFR2**), **station 11** at Gold Creek Bridge and **station 11.7** at Bearmouth had pollution index values in 2001 that were slightly greater than the long-term mean, while and **station 12** at Bonita had a 2001 value slightly below the long-term mean value (Figure 36). **Station 13** at Turah had a pollution index value in 2001 that was essentially equal to the mean for the period of record (Figure 36). The mean pollution index value for **CFR2** during August 2001 was essentially equal to the mean for the period of record, indicating consistently good water quality over time (Figure 38).

Within Clark Fork reach 3 (**CFR3**), both **station 15.5** above Missoula and **station 18** at Shuffields had pollution index values that were slightly to moderately less than average in August 2001 (Figure 36). Reach **CFR3,** therefore, had a mean pollution index value during August 2001 that was less than the long-term average for the thirteen years of record, indicating a decline in water quality (Figure 38).

Clark Fork reach 4 (**CFR4**) consists of two stations, **station 20** at Harper Bridge and **station 22** at Huson. **Station 20, station 22** and reach **CFR4** had pollution index values in 2001 that were less than the long-term means, (Figures 36 and 38), again suggesting worsening water quality.

Station 24 near Superior and **station 25** above the Flathead River make up Clark Fork reach 5 (**CFR5**). **Station 24, station 25** and **CFR5** had pollution index values in 2001 that were slightly below the long-term mean values (Figures 36 and 38). The pollution index value for **station 27** above Thompson Falls Reservoir was at or slightly above average for August 2001 (Figure 36).

For upper Clark Fork Basin tributaries, the August 2001 pollution index value exceeded the long-term mean value at Blacktail Creek **station SF-1,** Mill-Willow Bypass **station MW2** and Silver Bow Creek **station 4.5** by a significant amount, while Warm Springs Creek **station 06** had a pollution index value the was only slightly greater than average (Figure 37). Of the three middle Clark Fork tributaries, Little Blackfoot River **station 10.2** had pollution index value that was moderately greater than average, while Flint Creek **station 11.5**, Rock Creek **station 12.5** and Blackfoot River **station**

14 had values only slightly greater than average for August 2001 (Figure 37). The pollution index for Bitterroot River **station 19** in August 2001 was very near the mean value for the years 1989-2001 (Figure 37).

Table 3. Estimated relative abundance of algal cells and rank by volume ( ) of diatoms and the five most abundant non-diatom genera, and number of non-diatom genera, by phylum, in periphyton samples collected from monitoring sites on the upper Clark Fork and tributaries during August 2001. VA = very abundant, A = abundant, VC = very common, C = common. Dominant phyla: Ch = Chlorophyta (green algae), Cy = Cyanophyta (blue-green algae)

taxa	stream/ station:	**BTC SF-1**	**SBC 00**	**SBC 01**	**SBC 2.5**	**MWB MW2**	**SBC 4.5**	**WSC 06**	**CFR 07**	**CFR 08**	**CFR 8.5**	**CFR 09**	**CFR 10**	**LBR 10.2**	**CFR 11**
Chlorophyta (green algae)															
Chaetophora														A(6)	
Cladophora			A(1)			A(2)	A(2)	VC(4)	VC(4)	VC(3)	A(2)	VC(2)	VA(1)	A(1)	VC(1)
Closterium														VC(5)	
Cosmarium					A(1)										
Gloeocystis			A(3)	VA(2)	C(5)										
Microspora		A(4)													
Oedogonium		VA(2)	C(6)			A(3)	A(3)	A(3)	A(2)	A(1)	VA(1)	VA(1)			
Rhizoclonium		C(6)													
Scenedesmus				VA(5)	VA(2)										
Spirogyra									C(6)						
Stigeoclonium				VA(1)											
Chrysophyta (golden algae)															
Diatoms (Bacillariophyceae)		VA(3)	VA(2)	VA(4)	VC(3)	VA(4)	VA(4)	VA(1)	VA(3)	A(4)	A(4)	A(4)	VC(3)	VA(3)	VC(3)
Tribonema				C(6)											
Vaucheria		VA(1)		A(3)				C(6)						A(4)	
Cyanophyta (blue-green algae)															
Calothrix															VC(6)
Chamaesiphon						VA(6)	VA(6)			A(6)			A(6)		VA(5)
Microchaete													VC(4)		
Nostoc						VA(1)	VA(1)	VA(2)	VA(1)	A(2)	A(3)	A(3)	VA(2)	VA(2)	VA(2)
Oscillatoria		A(5)	VC(5)		C(4)			A(5)	A(5)		C(6)	C(5)			
Phormidium			A(4)			VA(5)	VA(5)				VA(5)	VC(6)	VC(5)		A(4)
Rhodophyta (red algae)															
Audouinella										VC(5)					
Total Non-Diatom Genera		12	12	7	5	12	14	11	11	10	11	11	13	16	13
No. Dominant Genera		8	9	6	4	9	10	7	7	6	7	7	8	11	8
No. Green Algae Genera		6	6	4	3	4	3	3	4	2	2	3	2	3	2
No. Blue-Green Algae Genera		1	3	0	1	4	7	3	3	3	5	4	6	6	6
No. Other Genera		1	0	2	0	1	0	1	0	1	0	0	0	2	0
Dominant Phylum		Ch	Ch	Ch	Ch	Ch	Cy	Ch	Ch/Cy	Ch	Ch/Cy	Ch	Cy	Ch/Cy	Cy

Table 4. Estimated relative abundance of algal cells and rank by volume ( ) of diatoms and the five most abundant non-diatom genera, and number of non-diatom genera, by phylum, in periphyton samples collected from monitoring sites on the middle and lower Clark Fork and tributaries during August 2001. VA = very abundant, A = abundant, VC = very common, C = common. Dominant phyla: Ch = Chlorophyta (green algae), Cy = Cyanophyta (blue-green algae)

taxa — stream/station:	FTC 11.5	CFR 11.7	CFR 12	RKC 12.5	CFR 13	BFR 14	CFR 15.5	CFR 18	BRR 19	CFR 20	CFR 22	CFR 24	CFR 25	CFR 27
Chlorophyta (green algae)														
Ankistrodesmus				VA(5)										
Chaetophora				A(2)		VA(3)								
Cladophora	VC(3)	VC(2)	VC(2)		VC(2)		A(1)	VC(3)		VC(2)	VC(2)	VC(1)	VC(2)	VC(2)
Closterium							VC(5)			VC(5)	A(4)			
Cosmarium						VC(6)		A(4)		A(4)	A(5)		A(4)	VC(4)
Oedogonium							A(2)		C(5)					
Pediastrum														C(6)
Scenedesmus									VC(6)				A(6)	A(5)
Stigeoclonium					A(4)			A(5)	A(3)	A(3)				
Ulothrix				VC(3)										
Chrysophyta (golden algae)														
Diatoms (Bacillariophyceae)	VA(2)	A(4)	VC(4)	VA(1)	VA(3)	VA(4)	VA(3)	VA(1)	VA(1)	VA(1)	VA(1)	A(2)	VA(1)	VA(1)
Cyanophyta (blue-green algae)														
Chamaesiphon		VA(3)	VA(3)		VA(6)							VA(6)	VA(5)	
Dichothrix						VA(2)								VC(3)
Nostoc	VA(1)	VA(1)	VA(1)		VA(1)	A(5)	VC(6)					A(5)		
Oscillatoria	VA(4)	VC(5)				VA(1)		VA(2)	VA(2)			A(3)		
Phormidium	A(6)	A(6)	A(5)				VA(4)	VA(6)			VA(3)	VA(4)	VA(3)	
Rivularia				A(4)										
Tolypothrix				VC(6)	A(5)									
Phaeophyta (brown algae)														
Heribaudiella									VC(4)	VC(6)				
Rhodophyta (red algae)														
Asterocystis											VC(6)			
Audouinella	VC(5)		C(6)											
Total Non-Diatom Genera	12	12	12	16	9	16	16	17	11	12	15	15	14	16
No. Dominant Genera	10	10	8	11	7	10	10	10	7	10	10	13	8	10
No. Green Algae Genera	5	3	1	5	3	5	6	6	4	6	6	8	4	7
No. Blue-Green Algae Genera	4	6	6	5	4	4	4	4	2	3	3	4	3	2
No. Other Genera	1	1	1	1	0	1	0	0	1	1	1	1	1	1
Dominant Phylum	Cy	Cy	Cy	Ch	Cy	Cy	Ch	Ch	Ch	Ch	Ch	Ch/Cy	Ch	Ch

Table 5. Criteria for rating levels of biological integrity, environmental impairment or natural stress, and aquatic life use support in wadable **mountain streams** of Montana using selected metrics for benthic diatom associations (Bahls 1993). The lowest rating for any one metric is the overall rating for the study site. Beneficial use support ratings and Diversity Index criteria reflect changes to the original criteria that are as yet unpublished (Dr. Loren Bahls, pers. com.).

Biological Integrity/ Impairment or Natural Stress/ Use Support	Diversity Index[1] (Shannon)	Pollution Index[2]	Siltation Index[3]	Disturbance Index[4]	Number of Species Counted	Percent Dominant Species	Similarity Index[5]	Bioassess-ment Protocol I Score
Excellent/None/ Full Support	>2.99	>2.50	<20.0	<25.0	>29	<25.0	>59.9	4
Good/Minor/ Full Support	2.00-2.99	2.01-2.50	20.0-39.9	25.0-49.9	20-29	25.0-49.9	40.0-59.9	3
Fair/Moderate/ Partial Support	1.00-1.99	1.50-2.00	40.0-59.9	50.0-74.9	10-19	50.0-74.9	20.0-39.9	2
Poor/Severe/ Nonsupport	<1.00	<1.50	>59.9	>74.9	<10	>74.9	<20.0	1

[1]Shannon diversity and species richness may increase somewhat in naturally nutrient-poor waters in response to slight to moderate increases in nutrients or sediment.

[2]This is a composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species; responds to **organic** pollution only.

[3]Computed as the sum of the percent abundances of all species in the genera *Navicula, Nitzschia* and *Surirella.* These are common genera of predominantly motile taxa that are able to maintain their positions on the substrate surface in depositional environments.

[4]Computed as the percent abundance of *Achnanthes minutissima.* This attached taxon typically dominates early successional stages of benthic diatom associations and resists chemical, physical and biological disturbances in the form of metal toxicity, substrate scour by high flows and fast currents, and grazing by macroinvertebrates (Barbour *et al.* 1997).

[5]The Similarity Index or Percent Community Similarity (Whittaker 1952) may be used to gauge the relative amount of impairment or recovery that occurs between adjacent study sites: >59.9% = very similar floras, no change; 40.0-59.9% = somewhat similar floras, minor change; 20.0-39.9% = somewhat dissimilar floras, moderate change; <20.0% = very dissimilar floras, major change.

Table 6. Percent abundance of major diatom species and values of selected diatom association metrics for periphyton samples collected from the upper Clark Fork and tributaries during August 2001. <u>Underlined values</u> indicate full support of aquatic life uses with minor impairment; **bold values** indicate partial support of aquatic life uses with moderate impairment; **<u>underlined and bold values</u>** indicate nonsupport of aquatic life uses with severe impairment based on criteria for wadable mountain streams in Table 5 (Bahls 1993). Values for Similarity Index (Whittaker 1952) are between adjacent mainstem stations. Arrows (> <) denote comparisons of sites above and below intervening tributaries.

Species/Metric (Pollution Tolerance)	Stream/ Station:	**BTC SF-1**	**SBC 00**	**SBC 01**	**SBC 2.5**	**MWB MW2**	**SBC 4.5**	**WSC 06**	**CFR 07**	**CFR 08**	**CFR 8.5**	**CFR 09**	**CFR 10**	**LBR 10.2**	**CFR 11**
Achnanthes biasolettiana (3)		15.95													
Achnanthes minutissima (3)								8.33			12.10	8.27			
Amphora pediculus (3)										13.69					
Caloneis molaris (3)					6.64										
Cocconeis pediculus (3)						45.23	18.57			12.85	6.71		7.77	8.33	
Cocconeis placentula (3)						6.69	6.92		6.11	12.36		5.93	6.12	35.14	4.47
Cymbella microcephala (2)											11.38	9.75			
Cymbella silesica (3)															
Epithemia sorex (3)			17.84			19.33	17.35	9.52	10.42	11.52	5.75		37.81	11.35	52.60
Fragilaria capucina (2)					8.90										
Fragilaria construens (3)		48.69	12.26									5.68		14.98	4.35
Gomphonema minutum (3)						3.59									
Gomphonema parvulum (1)			9.10	68.67	9.73	5.45									
Melosira varians (2)								6.31							
Navicula cryptotenella (2)							14.44		19.28		33.17	27.41	11.43		8.83
Navicula minima (1)					31.91										
Navicula seminulum (1)				8.07											
Navicula tripunctata (3)									5.51						
Nitzschia dissipata (3)								11.90							
Nitzschia inconspicua (2)										7.92			9.19		
Nitzschia palea (1)			10.68	16.02	8.78										
Nitzschia paleacea (2)							9.71								
Rhoicosphenia abbreviata (3)									11.26						
Synedra ulna (2)			11.89												
Species Richness		65	37	**17**	<u>28</u>	38	34	71	58	48	47	51	44	41	39
Percent Dominant Species		<u>48.69</u>	17.84	**68.67**	<u>31.91</u>	<u>45.23</u>	18.57	11.90	19.28	13.69	<u>33.17</u>	<u>27.41</u>	<u>37.81</u>	<u>35.14</u>	**52.60**
Shannon Species Diversity		3.33	3.77	**1.59**	3.37	<u>2.93</u>	3.70	4.77	4.47	4.11	3.66	4.11	3.38	3.43	<u>2.97</u>
Pollution Index		2.78	<u>2.06</u>	**<u>1.06</u>**	**1.64**	2.83	2.58	2.68	2.62	2.68	<u>2.47</u>	<u>2.47</u>	2.64	2.90	2.77
Siltation Index		17.02	<u>29.61</u>	<u>27.47</u>	**57.53**	5.08	<u>34.34</u>	<u>32.74</u>	<u>39.40</u>	<u>27.01</u>	**42.16**	<u>36.67</u>	<u>29.09</u>	15.34	<u>22.97</u>
Disturbance Index		0.83	1.58	0.72	6.17	2.48	0.49	8.33	4.07	3.00	12.10	8.27	2.00	1.33	1.09
Percent Epithemiaceae		0.00	0.00	0.00	0.00	19.45	17.35	0.00	10.42	11.64	5.75	2.47	38.04	11.59	53.45
Similarity Index		**27.54**	**25.45**	**24.38**	>	**<u>7.87</u>**	< >	<u>56.58</u>	< <u>48.43</u>	<u>46.50</u>	73.28	**39.42**	>	72.77	< >

Table 7. Percent abundance of major diatom species and values of selected diatom association metrics for periphyton samples collected from the middle and lower Clark Fork and tributaries during August 2001. <u>Underlined values</u> indicate full support of aquatic life uses with minor impairment; **bold values** indicate partial support of aquatic life uses with moderate impairment; <u>**underlined and bold values**</u> indicate nonsupport of aquatic life uses with severe impairment based on criteria for wadable mountain streams in Table 5 (Bahls 1993). Values for Similarity Index (Whittaker 1952) are between adjacent mainstem stations. Arrows (> <) denote comparisons of sites above and below intervening tributaries.

Species/Metric (Pollution Tolerance) Stream/ Station:	**FTC 11.5**	**CFR 11.7**	**CFR 12**	**RKC 12.5**	**CFR 13**	**BFR 14**	**CFR 15.5**	**CFR 18**	**BRR 19**	**CFR 20**	**CFR 22**	**CFR 24**	**CFR 25**	**CFR 27**
Achnanthes minutissima (3)						6.47	7.40		10.00	5.60			5.39	10.23
Amphora pediculus (3)			4.33											
Cocconeis pediculus (3)		6.05												
Cocconeis placentula (3)		7.16	4.45		4.78	4.07			7.23		5.68	8.28	8.81	6.90
Cymbella affinis (3)						8.38				8.45	6.04	8.78		14.74
Cymbella caespitosa (2)											4.83			
Cymbella elginensis (3)				6.14										
Cymbella silesiaca (3)				10.59				4.63						
Cymbella turgidula (3)						20.84				6.31		5.93		8.32
Diatoma moniliformis (2)					6.34		6.80							
Epithemia sorex (3)		21.85	34.54	9.39	23.92	11.98	11.04	10.32					17.38	
Fragilaria construens (3)		8.40	4.81	15.40			8.01						4.41	
Fragilaria pinnata (3)				8.78										
Gomphonema minutum (3)	6.40											8.53		
Gomphonema pumilum (3)									14.22					
Navicula capitatoradiata (2)							9.34	12.81	16.14	16.43	14.37	9.64	11.51	
Navicula cryptotenella (2)	16.63	8.77	21.30		13.04									
Navicula reichardtiana (2)					3.35									
Navicula tripunctata (3)	7.64													
Nitzschia fonticola (3)								4.51			7.85			
Nitzschia inconspicua (2)	7.14													
Nitzschia paleacea (2)								5.93	8.67	7.98				
Rhoicosphenia abbreviata (3)	7.64													
Synedra ulna (2)														7.13
Species Richness	53	55	54	60	57	57	64	51	56	53	52	54	58	74
Percent Dominant Species	16.63	21.85	<u>34.54</u>	15.40	23.92	20.84	11.04	12.81	16.14	16.43	14.37	8.78	17.38	14.74
Shannon Species Diversity	4.66	4.43	3.64	4.51	4.33	4.41	4.88	4.85	4.34	4.62	4.84	4.83	4.69	4.90
Pollution Index	2.56	2.71	2.62	2.77	2.66	2.84	2.59	2.56	2.61	2.53	2.58	2.65	2.64	2.69
Siltation Index	**52.71**	<u>25.68</u>	<u>35.14</u>	17.21	<u>28.35</u>	10.66	<u>33.25</u>	<u>37.60</u>	**45.18**	**42.14**	<u>37.68</u>	<u>27.44</u>	<u>25.95</u>	14.15
Disturbance Index	1.11	1.60	0.60	3.25	1.67	6.47	7.40	4.39	10.00	5.60	4.11	4.57	5.39	10.23
Percent Epithemiaceae	3.08	23.09	35.62	10.35	24.52	12.93	11.89	10.32	0.00	0.95	1.21	2.47	19.34	0.59
Similarity Index	64.46	< 65.57	>	67.47	< >	63.30	< 71.45	>	65.44	< 76.35	73.38	63.68	53.13	

Table 8. Ratings for biological integrity, aquatic life impairment and beneficial use support at monitoring stations on the upper Clark Fork and tributaries during August 2001, using criteria in Table 5 and diatom association metrics in Table 6.

Parameter	Stream/ Station:	**BTC SF-1**	**SBC 00**	**SBC 01**	**SBC 2.5**	**MWB MW2**	**SBC 4.5**	**WSC 06**	**CFR 07**	**CFR 08**	**CFR 8.5**	**CFR 09**	**CFR 10**	**LBR 10.2**	**CFR 11**
Protocol I Low Score		3	3	1	2	3	3	3	3	3	2	3	3	3	2
Biological Integrity		good	good	poor	fair	good	good	good	good	good	fair	good	good	good	fair
Aquatic Life Impairment		minor	minor	severe	moderate	minor	minor	minor	minor	minor	moderate	minor	minor	minor	moderate
Beneficial Use Support		full	full	non-	partial	full	full	full	full	full	partial	full	full	full	partial
Limiting Metric(s)		% dom	pollution siltation	pollution	pollution siltation	% dom diversity	siltation	siltation	siltation	siltation	siltation	% dom pollution siltation	% dom siltation	% dom	% dom

Table 9. Ratings for biological integrity, aquatic life impairment and beneficial use support at monitoring stations on the middle and lower Clark Fork and tributaries during August 2001, using criteria in Table 5 and diatom association metrics in Table 7.

Parameter	Stream/ Station:	**FTC 11.5**	**CFR 11.7**	**CFR 12**	**RKC 12.5**	**CFR 13**	**BFR 14**	**CFR 15.5**	**CFR 18**	**BRR 19**	**CFR 20**	**CFR 22**	**CFR 24**	**CFR 25**	**CFR 27**
Protocol I Score		2	3	3	4	3	4	3	3	2	2	3	3	3	4
Biological Integrity		fair	good	good	excellent	good	excellent	good	good	fair	fair	good	good	good	excellent
Aquatic Life Impairment		moderate	minor	minor	none	minor	none	minor	minor	moderate	moderate	minor	minor	minor	none
Beneficial Use Support		partial	full	full	full	full	full	full	full	partial	partial	full	full	full	full
Limiting Metric(s)		siltation	siltation	% dom siltation	none	siltation	none	siltation	siltation	siltation	siltation	siltation	siltation	siltation	none

Figure 3. Number of genera of dominant non-diatom algae at Clark Fork and tributary stations during August 2001.

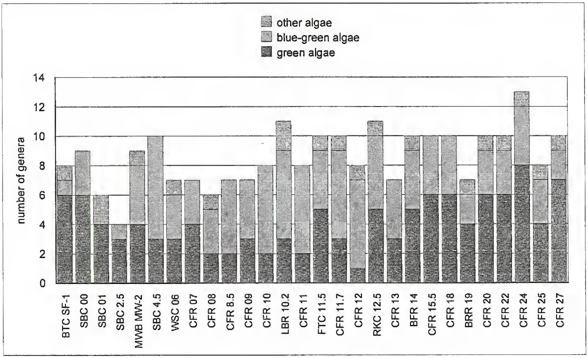


Figure 4. Percent community similarity of diatom floras between adjacent mainstem Silver Bow Creek and Clark Fork stations, August 2001.

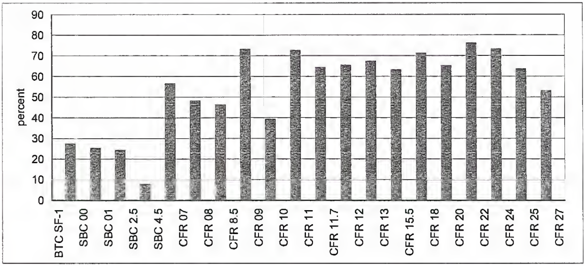


Figure 5. Shannon diversity index values for diatom associations from the Clark Fork and tributaries during August 2001.

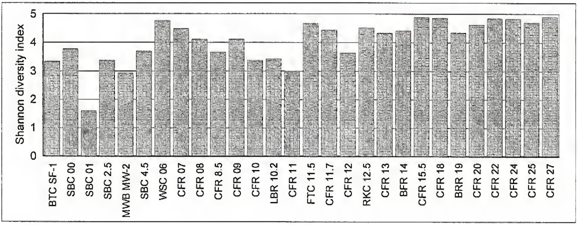


Figure 6. Pollution index values for diatom associations from the Clark Fork and tributaries during August 2001.

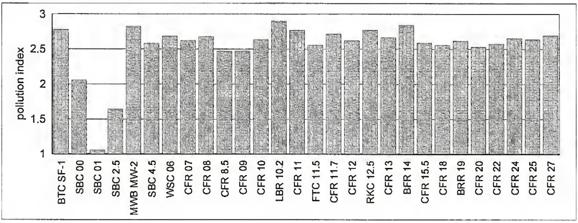


Figure 7. Siltation index values for diatom associations from the Clark Fork and tributaries during August 2001.

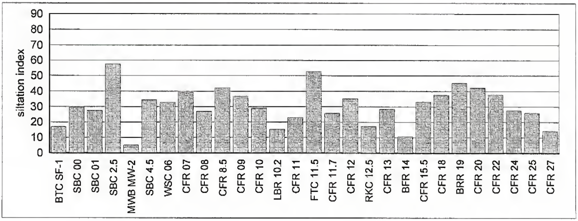


Figure 8. Pollution index values for Blacktail Creek above Grove Gulch (station SF-1), 1993-2001.

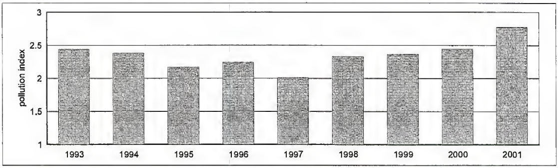


Figure 9. Pollution index values for Silver Bow Creek above the Butte WWTP (station 00), 1989-2001.

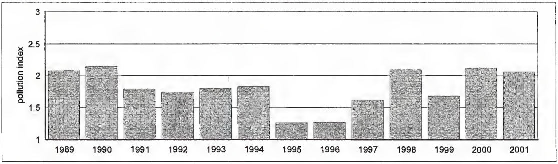


Figure 10. Pollution index values for Silver Bow Creek below the Butte WWTP (station 01), 1989-2001.

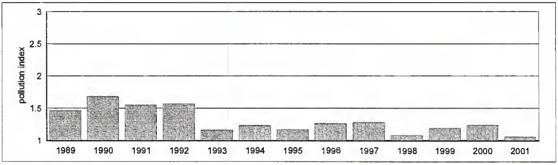


Figure 11. Pollution index values for Silver Bow Creek at Opportunity (station 2.5), 1989-2001. (station 03, 1989-91; not sampled in 1992).

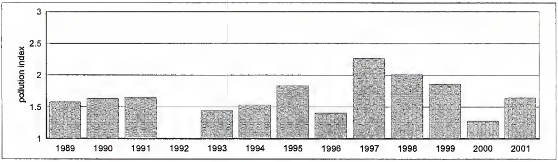


Figure 12. Pollution index values for Mill Creek-Willow Creek Bypass near mouth (station MW2), 1989-2001. (station 05, 1989-92; not sampled in 1993-98).

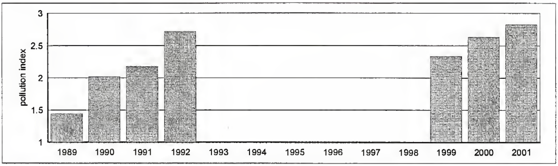


Figure 13. Pollution index values for Silver Bow Creek below Warms Springs Ponds (station 4.5), 1989-2001. (station 04, 1989-91; not sampled in 1992).

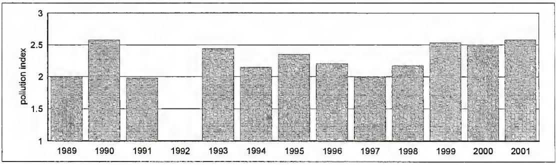


Figure 14. Pollution index values for Warm Springs Creek near mouth (station 06), 1989-2001.

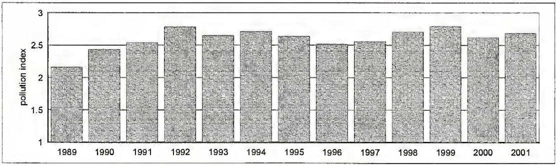


Figure 15. Pollution index values for Clark Fork below Warm Springs Creek (station 07), 1989-2001.

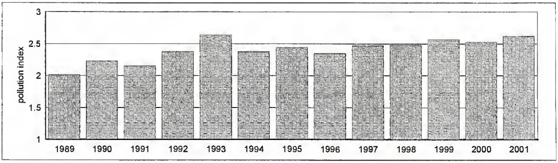


Figure 16. Pollution index values for Clark Fork at Dempsey (station 08), 1989-2001; (not sampled in 1993-1997).

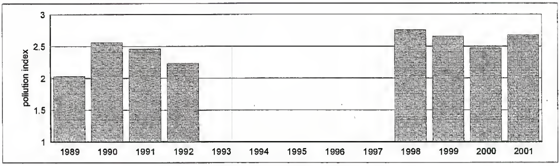


Figure 17. Pollution index values for Clark Fork at Sager Lane (station 8.5), 1989-2001; (not sampled 1989, 1993-1997).

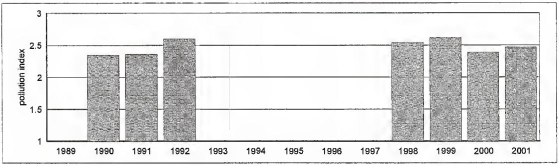


Figure 18. Pollution index values for Clark Fork at Deer Lodge (station 09), 1989-2001.

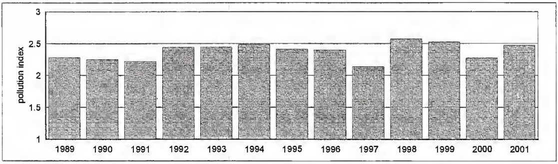


Figure 19. Pollution index values for Clark Fork above the Little Blackfoot River (station 10), 1989-2001.

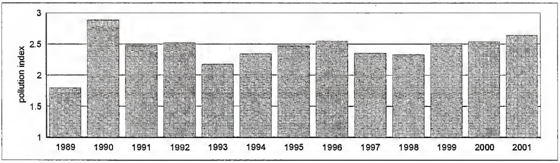


Figure 20. Pollution index values for Little Blackfoot River near mouth (station 10.2), 1993-2001.

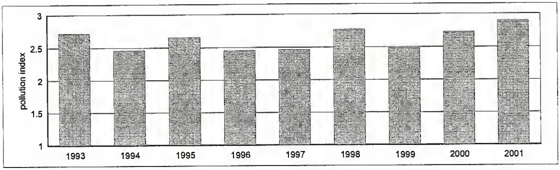


Figure 21. Pollution index values for Clark Fork at Gold Creek Bridge (station 11), 1989-2001.

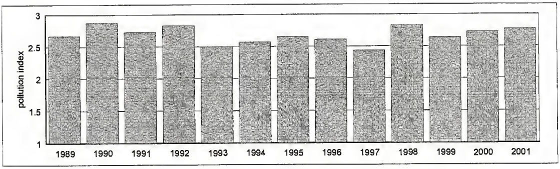


Figure 22. Pollution index values for Flint Creek at new Chicago (station 11.5), 1993-2001.

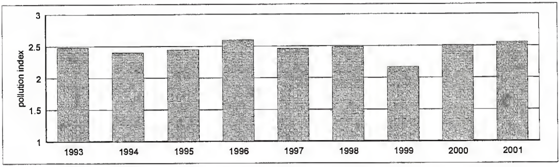


Figure 23. Pollution index values for Clark Fork at Bearmouth (station 11.7), 1993-2001.

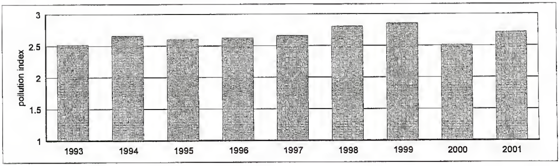


Figure 24. Pollution index values for Clark Fork at Bonita (station 12), 1989-2001.

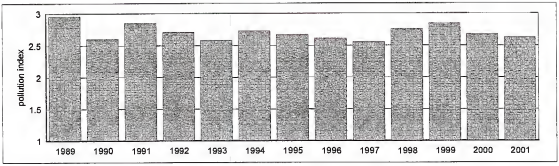


Figure 25. Pollution index values for Rock Creek near Clinton (station 12.5), 1993-2001.

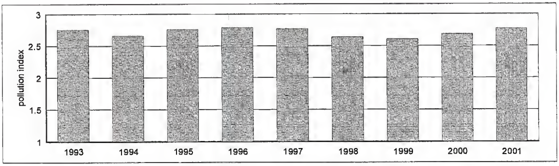


Figure 26. Pollution index values for Clark Fork at Turah (station 13), 1989-2001.

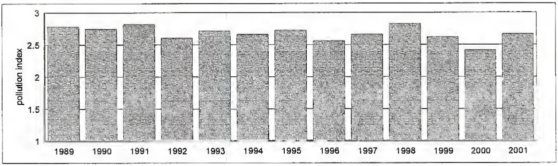


Figure 27. Pollution index values for Blackfoot River near mouth (station 14), 1989-2001.

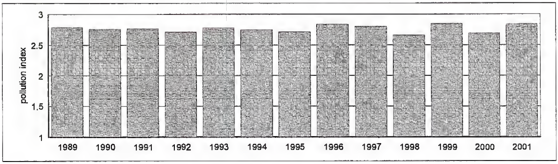


Figure 28. Pollution index values for Clark Fork above Missoula (station 15.5), 1989-2001.

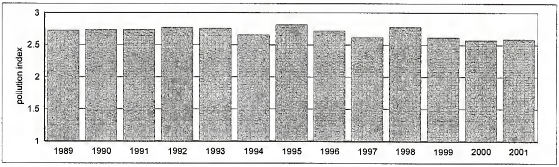


Figure 29. Pollution index values for Clark Fork at Shuffields (station 18), 1989-2001.

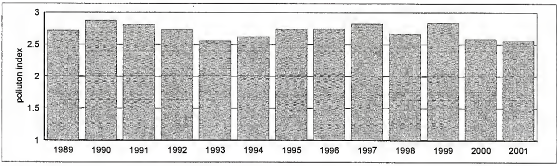


Figure 30. Pollution index values for Bitterroot River near mouth (station 19), 1989-2001.

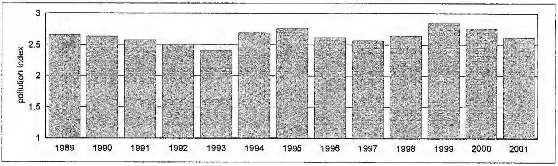


Figure 31. Pollution index values for Clark Fork at Harper Bridge (station 20), 1989-2001.

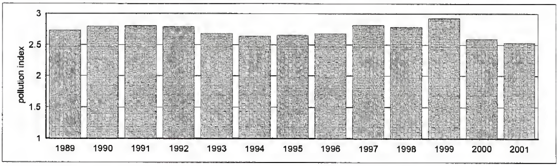


Figure 32. Pollution index values for Clark Fork at Huson (station 22), 1989-2001 (not sampled in 2000).

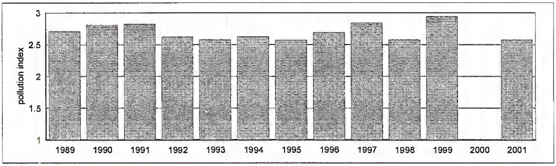


Figure 33. Pollution index values for Clark Fork near Superior (station 24), 1989-2001.

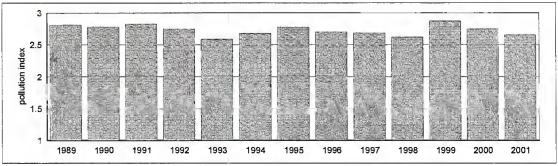


Figure 34. Pollution index values for Clark Fork above Flathead River (station 25), 1989-2001.

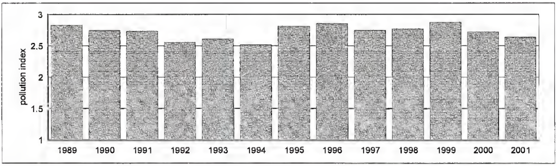


Figure 35. Pollution index values for Clark Fork above Thompson Falls Reservoir (station 27), 1989-2001.

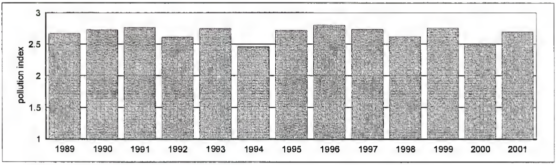
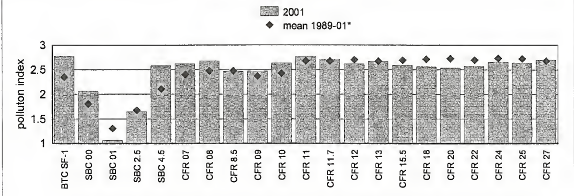
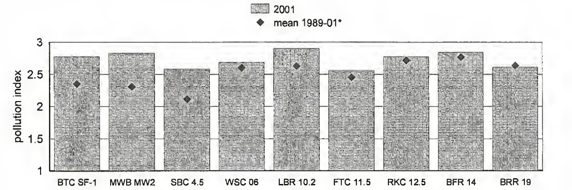


Figure 36. Pollution index values for 19 mainstem stations during August 2001, and long-term mean values for the period 1989-2001*.



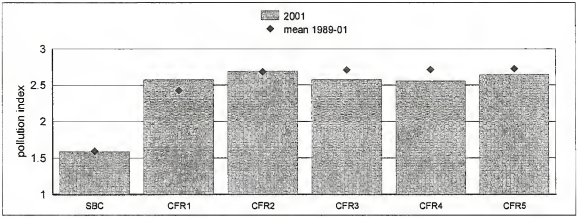
*SF-1 and 11.7: mean for 1993-01; 08: mean 1989-92, 1998-01; 8.5: mean 1990-92, 1998-01; 22: 1989-1999, 2001

Figure 37. Pollution index values for selected Clark Fork tributaries during August 2001, and long-term mean values for the period 1989-2001*.



*BTC SF-1, LBR 10.2, FTC 11.5, and RKC 12.5: mean 1993-01; MWB MW2: mean 1989-92, 1999-01

Figure 38. Mean pollution index values in Clark Fork reaches* during August 2001 and the period 1989-2001.



*SBC: stations 00, 01 and 2.5; CFR1: stations 07, 08, 8.5, 09 and 10; CFR2: stations 11, 11.7, 12 and 13; CFR3: stations 15.5 and 18; CFR4: stations 20 and 22; CFR5: stations 24 and 25.

CONCLUSIONS

1. In the Silver Bow Creek headwaters upstream of the Butte Metro Wastewater Treatment Plant (WWTP) discharge, metrics for both non-diatom and diatom algae associations indicated good biological integrity with minor impairment of aquatic life with in 2001. Beneficial uses were fully supported. Downstream of the Butte Metro WWTP, algal metrics indicated poor biological integrity and severe aquatic life impairment at Rocker, and beneficial uses were not supported. Silver Bow Creek at Opportunity, above the Warm Springs Ponds, had fair biological integrity with moderate aquatic life impairment, and only partially supported beneficial uses. In Silver Bow Creek downstream of the Warm Springs Ponds, biological integrity was good, aquatic life impairment minor and beneficial uses fully supported in 2001.

2. The reach of Silver Bow Creek above the Butte Metro WWTP discharge, re-constructed in 1998 as part of the Super Fund Program's Colorado Tailings clean-up and remediation, appears to have stabilized and may have reached its full potential, given the natural and man-made limitations imposed on the reach. Significant improvements in biological integrity and beneficial use support have been achieved.

3. Silver Bow Creek between Butte and the Warm Springs Ponds continued to be the most heavily impaired stream reach in 2001. Excessive concentrations of biogenic wastes, in the form of secondary-treated municipal wastewater, as well as sediment and toxic heavy metals from historic floodplain deposits were to blame. While Superfund remediation efforts have made progress between Lower Area One and Rocker and are proceeding downstream with tailings removal and channel reconstruction, water quality in this reach will continue to be limited by the Butte WWTP.

4. Significant improvement in biological integrity in Silver Bow Creek below the Warm Springs ponds in August 2001, as indicated by the non-diatom and diatom metrics, reaffirms the importance of the treatment pond system to the health of the upper Clark Fork. The ponds continue to effectively trap and buffer sediment, toxic metals and nutrients transported by Silver Bow Creek from the upper drainage.

5. The Mill Creek-Willow Creek Bypass continues to provide a significant volume clean , high quality water to benefit the biota in the upper Clark Fork. Algal metrics indicated good biological integrity and full beneficial use support in 2001, several years after tailings removal and channel reconstruction under the Super Fund program. Indications are that historic intermittent bouts of heavy metals pollution to the upper Clark Fork from the bypass channel have been mitigated.

6. A diverse algal flora in Warm Springs Creek in 2001 indicated good biological integrity, a largely unimpaired biota and full support of beneficial uses. Warm Springs Creek remains a primary provider of high quality water to the Clark Fork headwaters.

7. Biological integrity in the upper Clark Fork between Warm Springs Creek and the Little Blackfoot River was generally good during August 2001, with beneficial uses fully supported. Good

streamflow was present at the head of the Clark Fork just below the confluences of Mill-Willow Bypass, Silver Bow Creek and Warm Springs Creek, but was steadily depleted downstream by heavy irrigation withdrawals compounded by extended drought conditions. Despite apparently elevated stress levels, only the Clark Fork at Sager Lane had greater than minor impairment of aquatic life, and less than full support of beneficial uses. Siltation was the principal impact indicated by diatom metrics, possibly resulting from inadequate flushing flows over several seasons. Low streamflows may have had a positive effect on biological integrity between Warm Springs Creek and the Little Blackfoot River by reducing bank erosion and sediment transport in this reach, which has generally poor streambank conditions.

8. Clark Fork stations between the Little Blackfoot River and Blackfoot River in 2001 generally had good biological integrity, with minor impairment of aquatic life due primarily to sediment, as indicated by the algal metrics. Beneficial uses were fully supported at all but one station.

9. The Little Blackfoot River had good biological integrity with minor aquatic life impairment in 2001, while Flint Creek had only fair biological integrity with moderate impairment due to sediment impacts. Rock Creek and the Blackfoot River were rated as unimpaired, with excellent biointegrity and full support of beneficial aquatic life uses during August 2001. The Blackfoot River and Rock Creek continue to be major contributors of high-quality water to the Clark Fork. The Bitterroot River was rated as only partially supporting beneficial uses, with fair biological integrity and moderate impairment of aquatic life due to sediment. This may be related to the severe forest fires that ravaged large areas of the Bitterroot River drainage during the summer of 2000.

10. The Clark Fork stations immediately above Missoula and below Missoula's wastewater treatment plant (WWTP) discharge (at Shuffields) were both rated as having good biological integrity with only minor impairment of aquatic life. The Missoula WWTP discharge did not have a significant impact on the Clark Fork in August 2001, as evidenced by very similar algal communities and metric values at these stations.

11. The Clark Fork station at Harper Bridge, downstream of the Bitterroot River, was rated as having only fair biological integrity with moderate aquatic life impairment due to sediment. This may be related to the sediment problems indicated in the Bitterroot River in 2001, to impacts of the Missoula urban area, or both. The Clark Fork at Huson, downstream of the Smurfit-Stone Container Corporation Frenchtown Mill, was rated as having good biological integrity with only minor aquatic life impairment in 2001. Any negative impacts on the Clark Fork biota caused by seepage from the Frenchtown Mill's wastewater ponds was not apparent in the algal metrics, and beneficial uses were fully supported in this reach.

12. The two Clark Fork stations between Superior and the Flathead River had good biological integrity with minor impairment of aquatic life, and fully supported beneficial uses in August 2001. The Clark Fork above Thompson Falls Reservoir (and below the Flathead River) had excellent biological integrity with an aquatic biota that was unimpaired in 2001.

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APPENDIX A
2001 Non-diatom algae
Estimated relative abundance and biovolume

Appendix A

Estimated relative abundance and biovolume contribution rank ( ) of diatoms and genera of non-diatom algae in periphyton samples from Clark Fork Basin biological monitoring, 2001.
R=rare; C=common; VC=very common; A=abundant; VA=very abundant

STREAM:	CFR	BRR	CFR	CFR	CFR	CFR	CFR
STATION NUMBER:	**18**	**19**	**20**	**22**	**24**	**25**	**27**
SAMPLE NUMBER:	0676U	0278Z	272AA	273AE	0901R	0903R	0905V
2001 SAMPLING DATE:	8/4	8/4	8/4	8/5	8/5	8/5	8/5
Bacillariophyta (diatoms)							
All genera collectively	VA(1)	VA(1)	VA(1)	VA(1)	A(2)	VA(1)	VA(1)
Chlorophyta (green algae)							
Ankistrodesmus	R	R		A(8)	A(9)		VC(10)
Bulbochaete							R
Chaetophora				R		R	C(9)
Cladophora	VC(3)	R	VC(2)	VC(2)	VC(1)	VC(2)	VC(2)
Closterium	VC(7)		VC(5)	A(4)	C(11)	C(7)	C(7)
Coelastrum	R			R	C(14)		R
Cosmarium	A(4)	C(7)	A(4)	A(5)	VC(8)	A(4)	VC(4)
Euastrum	R						
Gloeocystis	R	R		R			
Gongrosira					R		
Oedogonium	C(9)	C(5)					R
Pediastrum		R	R	R	C(13)	R	C(6)
Scenedesmus	C(10)	VC(6)	VC(10)	VC(9)	VC(10)	A(6)	A(5)
Staurastrum			R	R			
Stigeoclonium	A(5)	A(3)	A(3)	VC(7)	C(12)	R	R
Tetrasporopsis							R
Ulothrix	R		C(9)				
Cyanophyta (blue-green algae)							
Calothrix						R	
Chamaesiphon	C(11)		C(11)	VC(11)	VA(6)	VA(5)	
Dichothrix	R						VC(3)
Merismopedia					R		
Microchaete						C(9)	
Nostoc	C(8)				A(5)		
Oscillatoria	VA(2)	VA(2)	VC(7)	C(10)	A(3)	R	
Phormidium	VA(6)	C(8)	A(8)	VA(3)	VA(4)	VA(3)	C(11)
Tolypothrix	R						
Phaeophyta (brown algae)							
Heribaudiella		VC(4)	VC(6)			C(8)	C(8)
Rhodophyta (red algae)							
Asterocystis				VC(6)	VC(7)	R	R

STATION NUMBER:	**18**	**19**	**20**	**22**	**24**	**25**	**27**
TOTAL NON-DIATOM GENERA:	17	11	12	15	15	14	16
# DOMINANT GENERA:	10	7	10	10	13	8	10
# GREEN:	6	4	6	6	8	4	7
# BLUE-GREEN:	4	2	3	3	4	3	2
# OTHER:	0	1	1	1	1	1	1
DOMINANT PHYLUM:	Chlor	Chlor	Chlor	Chlor	Chlor/Cyan	Chlor	Chlor

Estimated relative abundance and biovolume contribution rank ( ) of diatoms and genera of non-diatom algae in periphyton samples from Clark Fork Basin biological monitoring, 2001.
R=rare; C=common; VC=very common; A=abundant; VA=very abundant

STREAM:	BTC	SBC	SBC	SBC	MWB	SBC	WSC
STATION NUMBER:	SF-1	00	01	2.5	MW-2	4.5	06
SAMPLE NUMBER:	1398I	0847P	0102V	0245K	1019J	1399I	1020P
2001 SAMPLING DATE:	8/8	8/8	8/8	8/8	8/8	8/8	8/7
Bacillariophyta (diatoms)							
All genera collectively	VA(3)	VA(2)	VA(4)	VC(3)	VA(4)	VA(4)	VA(1)
Chlorophyta (green algae)							
Ankistrodesmus	VC(9)	VC(9)	R				R
Cladophora	C(7)	A(1)			A(2)	A(2)	VC(4)
Closterium	C(8)				C(7)	R	C(7)
Coelastrum		R				R	
Cosmarium	R	C(7)	C(7)	A(1)			R
Gloeocystis		A(3)	VA(2)	C(5)	R		
Microspora	A(4)						
Microthamnion		R					
Oedogonium	VA(2)	C(6)			A(3)	A(3)	A(3)
Pediastrum	R	R			R		
Rhizoclonium	C(6)						
Scenedesmus	R	VC(8)	VA(5)	VA(2)		R	
Spirogyra							
Stigeoclonium			VA(1)	R	C(10)	VC(7)	R
Ulothrix							R
Chrysophyta (yellow-green algae)							
Tribonema			C(6)				
Vaucheria	VA(1)		A(3)				C(6)
Cyanophyta (blue-green algae)							
Amphithrix						VC(8)	
Anabaena					VC(8)		
Chamaesiphon		VC(10)			VA(6)	VA(6)	A(8)
Dactylococcopsis							R
Microchaete						C(11)	
Microcystis						C(9)	
Nostoc					VA(1)	VA(1)	VA(2)
Oscillatoria	A(5)	VC(5)		C(4)	R	C(10)	A(5)
Phormidium		A(4)			VA(5)	VA(5)	C(8)
Phaeophyta (brown algae)							
Heribaudiella						R	
Rhodophyta (red algae)							
Asterocystis					C(9)		
Audouinella	R						R
Higher Aquatic Plants							
mosses	x					x	x
macrophytes		x				x	
STATION NUMBER:	**SF-1**	**00**	**01**	**2.5**	**MW-2**	**4.5**	**06**
TOTAL NON-DIATOM GENERA:	12	12	7	5	12	14	13
# DOMINANT GENERA:	8	9	6	4	9	10	7
# GREEN:	6	6	4	3	4	3	3
# BLUE-GREEN:	1	3	0	1	4	7	3
# OTHER:	1	0	2	0	1	0	1
DOMINANT PHYLUM:	Chlor	Chlor	Chlor	Chlor	Chlor	Cyan	Chlor

Appendix A
Estimated relative abundance and biovolume contribution rank ( ) of diatoms and genera of non-diatom algae in periphyton samples from Clark Fork Basin biological monitoring, 2001.
R=rare; C=common; VC=very common; A=abundant; VA=very abundant

STREAM:	CFR	CFR	CFR	CFR	CFR	LBR	CFR
STATION NUMBER:	**07**	**08**	**8.5**	**09**	**10**	**10.2**	**11**
SAMPLE NUMBER:	0849S	1021K	1049G	0266Z	0850R	1400I	0556R
2001 SAMPLING DATE:	8/7	8/7	8/7	8/7	8/7	8/4	8/6
Bacillariophyta (diatoms)							
All genera collectively	VA(3)	A(4)	A(4)	A(4)	VC(3)	VA(3)	VC(3)
Chlorophyta (green algae)							
Ankistrodesmus			R	C(8)			
Chaetophora						A(6)	
Cladophora	VC(4)	VC(3)	A(2)	VC(2)	VA(1)	A(1)	VC(1)
Closterium	R		R			VC(5)	C(8)
Cosmarium						R	
Gongrosira							R
Mougeotia						R	
Oedogonium	A(2)	A(1)	VA(1)	VA(1)	C(7)		
Pediastrum				R	R		
Scenedesmus		R	R	R	R	R	
Spirogyra	C(6)						
Stigeoclonium	R			R	R		
Chrysophyta (yellow-green algae)							
Vaucheria						A(4)	
Cyanophyta (blue-green algae)							
Anabaena						R	
Calothrix			C(8)		R	R	VC(6)
Chamaesiphon	A(8)	A(6)	VC(7)	VC(7)	A(6)		VA(5)
Dichothrix		R			C(9)		
Microchaete	R	C(7)			VC(4)	C(11)	VC(7)
Microcystis	R	R					
Nostoc	VA(1)	A(2)	A(3)	A(3)	VA(2)	VA(2)	VA(2)
Oscillatoria	A(5)	R	C(6)	C(5)	C(8)	C(10)	R
Phormidium	VC(7)		VA(5)	VC(6)	VC(5)	C(12)	A(4)
Rivularia						VC(7)	C(9)
Tolypothrix						C(9)	R
Rhodophyta (red algae)							
Asterocystis							R
Audouinella		VC(5)	R	R	R	C(8)	R
Higher Aquatic Plants							
macrophytes	x						
mosses							

STATION NUMBER:	**07**	**08**	**8.5**	**09**	**10**	**10.2**	**11**
TOTAL NON-DIATOM GENERA:	11	10	11	11	13	16	13
# DOMINANT GENERA:	7	6	7	7	8	11	8
# GREEN:	4	2	2	3	2	3	2
# BLUE-GREEN:	3	3	5	4	6	6	6
# OTHER:	0	1	0	0	0	2	0
DOMINANT PHYLUM:	Chlor/Cyan	Chlor	Chlor/Cyan	Chlor	Cyan	Chlor/Cyan	Cyan

Appendix A

Estimated relative abundance and biovolume contribution rank ( ) of diatoms and genera of non-diatom algae in periphyton samples from Clark Fork Basin biological monitoring, 2001.

R=rare; C=common; VC=very common; A=abundant; VA=very abundant

STREAM:	FTC	CFR	CFR	RKC	CFR	BFR	CFR
STATION NUMBER:	11.5	11.7	12	12.5	13	14	15.5
SAMPLE NUMBER:	1401I	0652J	0557R	1402I	0558X	0752V	0897S
2001 SAMPLING DATE:	8/6	8/6	8/6	8/6	8/6	8/5	8/4
Bacillariophyta (diatoms)							
All genera collectively	VA(2)	A(4)	VC(4)	VA(1)	VA(3)	VA(4)	VA(3)
Chlorophyta (green algae)							
Ankistrodesmus			R	VA(5)			
Chaetophora				A(2)		VA(3)	
Cladophora	VC(3)	VC(2)	VC(2)	R	VC(2)		A(1)
Closterium	C(9)						VC(5)
Coelastrum							R
Cosmarium	R					VC(6)	VC(7)
Gloeocystis	C(11)						
Gongrosira		C(9)	R	R			
Mougeotia						C(8)	
Oedogonium	C(8)	C(7)				R	A(2)
Pediastrum						R	R
Scenedesmus		R	R	VC(12)	C(8)	C(11)	VC(9)
Spirogyra		R				C(9)	
Stigeoclonium	C(10)			C(11)	A(4)	R	VC(8)
Ulothrix				VC(3)		R	R
Cyanophyta (blue-green algae)							
Aphanocapsa				R			
Calothrix					R	R	
Chamaesiphon	A(7)	VA(3)	VA(3)		VA(6)		C(11)
Dichothrix	R	C(10)	C(8)			VA(2)	
Microchaete		C(11)	C(9)	R			
Nostoc	VA(1)	VA(1)	VA(1)	C(10)	VA(1)	A(5)	VC(6)
Oscillatoria	VA(4)	VC(5)	C(7)	VC(7)	R	VA(1)	C(10)
Phormidium	A(6)	A(6)	A(5)	VC(9)	A(7)		VA(4)
Rivularia				A(4)		VC(7)	
Tolypothrix			R	VC(6)	A(5)		
Phaeophyta (brown algae)							
Heribaudiella				R		C(10)	R
Rhodophyta (red algae)							
Asterocystis							R
Audouinella	VC(5)	C(8)	C(6)	C(8)		R	R
Higher Aquatic Plants							
macrophytes		x					
mosses		x	x				x
STATION NUMBER:	**11.5**	**11.7**	**12**	**12.5**	**13**	**14**	**15.5**
TOTAL NON-DIATOM GENERA:	12	12	12	16	9	16	16
# DOMINANT GENERA:	10	10	8	11	7	10	10
# GREEN:	5	3	1	5	3	5	6
# BLUE-GREEN:	4	6	6	5	4	4	4
# OTHER:	1	1	1	1	0	1	0
DOMINANT PHYLUM:	Cyan	Cyan	Cyan	Chlor	Cyan	Cyan	Chlor

APPENDIX B
2001 Diatom algae
Taxa, proportional counts and metrics

Appendix B

Diatom proportional count data, Clark Fork Basin biological monitoring, August 4-8, 2001.
PT = Pollution Tolerance class number; PRA = Percent Relative Abundance. A letter "p" denotes species encountered during floristic scan, but not during count.

STREAM:		BTC	SBC	SBC	SBC	MWB	SBC	WSC
STATION NUMBER:		SF-1	00	01	2.5	MW-2	4.5	06
SAMPLE NUMBER:		1398I	0847P	0102V	0245K	1019J	1399I	1020P
2001 SAMPLING DATE:		8/8	8/8	8/8	8/8	8/8	8/8	8/7
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Achnanthes biasolettiana	3	15.95						0.24
Achnanthes exigua	3	0.24						
Achnanthes laevis	3							0.12
Achnanthes lanceolata	2		4.00	2.05	1.78	0.37	1.33	1.43
Achnanthes lauenburgiana	2	0.24						
Achnanthes minutissima	3	0.83	1.58	0.72	6.17	2.48	0.49	8.33
Amphora inariensis	3							0.48
Amphora libyca	3	1.31						
Amphora pediculus	3	0.24				0.25	0.24	2.38
Amphora veneta	1						1.58	
Caloneis bacillum	2							0.24
Caloneis molaris	3				6.64			
Caloneis silicua	2				0.24			
Cocconeis pediculus	3	0.36				45.23	18.57	1.43
Cocconeis placentula	3	1.79	0.24		0.12	6.69	6.92	5.00
Cyclostephanos invisitatus	2	0.95	0.12					
Cyclotella atomus	2	0.24						
Cyclotella distinguenda	2							0.24
Cyclotella meneghiniana	2	0.48	2.31	0.12	0.12	0.12		0.12
Cymatopleura elliptica	2							0.12
Cymbella affinis	3							1.07
Cymbella cesatii	3							0.12
Cymbella descripta	3							0.24
Cymbella microcephala	2					0.50		
Cymbella minuta	2							5.60
Cymbella naviculiformis	3							0.24
Cymbella prostrata	3							0.24
Cymbella reichardtii	3							0.24
Cymbella silesiaca	3	1.31	17.84		6.17	0.50	0.24	9.52
Cymbella sinuata	3	0.24				0.12		2.38
Cymbella turgidula	3					0.12		0.60
Diatoma mesodon	3				0.24			0.12
Diatoma vulgaris	3	0.12		0.12		0.62	0.36	6.43
Didymosphenia geminata	3							0.36
Epithemia adnata	2					0.12		
Epithemia sorex	3					19.33	17.35	
Fragilaria bicapitata	2	0.12	0.61					
Fragilaria brevistriata	3	0.24				0.87		2.02
Fragilaria capucina	2	3.33	9.59	0.24	8.90	0.25	0.61	0.83
Fragilaria construens	3	48.69	12.26	0.36	0.71	0.87		4.52
Fragilaria leptostauron	3	0.12				1.12	0.24	1.19
Fragilaria nitzschioides	3				0.71			
Fragilaria parasitica	2	0.24	0.24				0.12	
Fragilaria pinnata	3	0.12	0.24			1.98	1.70	3.45
Fragilaria tenera	2						0.12	
Frustulia vulgaris	2	0.12						0.24
Gomphonema aquaemineralis	3					0.25	0.12	0.24
Gomphonema clavatum	2					0.25	1.21	
Gomphonema minusculum	3							0.12

Appendix B (continued)

STREAM:		BTC	SBC	SBC	SBC	MWB	SBC	WSC
STATION NUMBER:		SF-1	00	01	2.5	MW-2	4.5	06
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Gomphonema minutum	3	1.07				3.59	3.28	
Gomphonema olivaceum	3				0.12	0.12	0.24	
Gomphonema parvulum	1	1.07	9.10	68.67	9.73	5.45	3.28	0.12
Gomphonema pumilum	3					1.49		0.36
Gomphonema truncatum	3					0.12		0.12
Hantzschia amphioxys	2				0.12			
Mastogloia smithii	3					0.12		
Melosira varians	2	1.31	0.12					6.31
Meridion circulare	3	0.24	0.12					
Navicula agrestis	1		0.12					
Navicula atomus	1			0.36	0.47			
Navicula aurora	3		0.12					
Navicula bacilloides	3							0.12
Navicula bremensis	2							0.12
Navicula capitata	2	0.12						
Navicula capitatoradiata	2	0.12						2.14
Navicula cryptocephala	3	0.12						0.36
Navicula cryptotenella	2	0.12				3.47	14.44	4.64
Navicula decussis	3	1.07	0.24			0.25		0.24
Navicula elginensis	3	0.12	0.12					
Navicula gallica	2	0.12						
Navicula gregaria	2	1.07						
Navicula ignota	2	0.12			0.24			0.12
Navicula lanceolata	2	0.24						
Navicula libonensis	2	0.12						
Navicula menisculus	2	0.12				0.12		0.12
Navicula minima	1	0.83	7.04	1.33	31.91		0.24	
Navicula minuscula	1	0.12	0.24	0.84	0.36			0.12
Navicula oligotraphenta	3	0.36						
Navicula protracta	2	0.12						
Navicula pupula	2	0.24	0.97	0.12	0.47	0.12		0.24
Navicula reichardtiana	2					0.12	0.49	3.81
Navicula seminulum	1			8.07				
Navicula tripunctata	3	0.83				0.37	4.61	2.98
Navicula trivialis	2	0.71						0.24
Navicula veneta	1		0.24					
Neidium dubium	3							0.12
Nitzschia acicularis	2		0.49					
Nitzschia alpina	3	0.12	0.24					
Nitzschia amphibia	2	0.95	0.49		0.12		0.24	0.48
Nitzschia angustata	2							
Nitzschia archibaldii	2							0.12
Nitzschia capitellata	2			0.48				
Nitzschia communis	1		0.12					
Nitzschia dissipata	3	2.26	0.12			0.25	0.24	11.90
Nitzschia draveillensis	1							0.24
Nitzschia flexoides	2							0.48
Nitzschia fonticola	3	1.55	0.24				2.43	0.48
Nitzschia gracilis	2							0.12
Nitzschia hantzschiana	3	0.71	0.85					0.24
Nitzschia heufleriana	3							0.24
Nitzschia incognita	2							0.36
Nitzschia inconspicua	2	2.02	4.13			0.12	0.73	0.24
Nitzschia lacuum	3							0.12
Nitzschia linearis	2	0.95	0.73		0.24			0.60

Appendix B (continued)

STREAM:		BTC	SBC	SBC	SBC	MWB	SBC	WSC
STATION NUMBER:		SF-1	00	01	2.5	MW-2	4.5	06
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Nitzschia palea	1	0.48	10.68	16.02	8.78	0.12	0.97	0.24
Nitzschia paleacea	2					0.12	9.71	1.07
Nitzschia perminuta	3						0.24	0.24
Nitzschia recta	3	0.24						0.36
Nitzschia sociabilis	1	0.12						
Nitzschia supralitorea	2	0.48						
Nitzschia vermicularis	2	0.12						
Pinnularia microstauron	2	0.12						
Pinnularia viridis	2	0.24						
Rhoicosphenia abbreviata	3	0.12			0.24	1.49	6.92	0.12
Rhopalodia gibba	2					0.50	0.24	
Rhopalodia operculata	2		0.12					
Stauroneis smithii	2				0.24			0.12
Stephanodiscus hantzschii	2	0.60						
Surirella angusta	1	0.24	0.73	0.12	5.46			
Surirella brebissonii	2		0.73		6.76			
Surirella minuta	2	0.12	0.97	0.12	2.73			
Synedra acus	2						0.36	
Synedra ulna	2	0.36	11.89	0.24	0.24		0.12	0.12
Thalassiosira pseudonana	2	0.60						

STREAM:	BTC	SBC	SBC	SBC	MWB	SBC	WSC
STATION NUMBER:	SF-1	00	01	2.5	MW-2	4.5	06
METRIC							
Valves Counted:	840	824	830	843	807	824	840
Species Counted:	65	37	17	28	38	34	71
Shannon Diversity:	3.33	3.77	1.59	3.37	2.93	3.70	4.77
Pollution Index:	2.78	2.06	1.06	1.64	2.83	2.58	2.68
Siltation Index:	17.02	29.61	27.47	57.53	5.08	34.34	32.74
Disturbance Index:	0.83	1.58	0.72	6.17	2.48	0.49	8.33
Percent Epithemiaceae:	0.00	0.00	0.00	0.00	19.45	17.35	0.00
Total PRA PT Class 1:	2.86	28.28	95.42	56.70	5.58	6.07	0.71
Total PRA PT Class 2:	16.79	37.50	3.37	22.18	6.20	29.73	30.24
Total PRA PT Class 3:	80.36	34.22	1.20	21.12	88.23	64.20	69.05

Appendix B
Diatom proportional count data, Clark Fork Basin biological monitoring, August 4-8, 2001.
PT = Pollution Tolerance class number; PRA = Percent Relative Abundance. A letter "p" denotes species encountered during floristic scan, but not during count.

STREAM:		CFR	CFR	CFR	CFR	CFR	LBR	CFR
STATION NUMBER:		07	08	8.5	09	10	10.2	11
SAMPLE NUMBER:		0849S	1021K	1049G	0266Z	0850R	1400I	0556R
2001 SAMPLING DATE:		8/7	8/7	8/7	8/7	8/7	8/4	8/6
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Achnanthes biasolettiana	3		0.24	1.68	0.37			
Achnanthes lanceolata	2	0.60	0.96	0.48	0.37	0.47	1.69	0.97
Achnanthes minutissima	3	4.07	3.00	12.10	8.27	2.00	1.33	1.09
Amphora libyca	3		0.24	0.12				
Amphora pediculus	3	3.59	13.69	3.11	2.84	6.01	0.85	2.78
Amphora veneta	1	0.12						
Aulacoseira distans	3						0.12	
Aulacoseira italica	3						0.36	
Caloneis bacillum	2	0.24	0.12		0.12	0.12		
Cocconeis pediculus	3	2.75	12.85	6.71	1.60	7.77	8.33	2.06
Cocconeis placentula	3	6.11	12.36	5.03	5.93	6.12	35.14	4.47
Cyclotella meneghiniana	2		0.24		0.12	0.12	0.36	0.12
Cymatopleura solea	2							0.12
Cymbella affinis	3	0.48	0.24	0.12	0.12			0.12
Cymbella microcephala	2		0.60	11.38	9.75	0.82		
Cymbella minuta	2	1.68						
Cymbella reichardtii	3	0.24	4.56					
Cymbella silesiaca	3	3.23	0.36	0.48	1.60	1.30		0.97
Cymbella sinuata	3	1.92	2.64	1.44	2.35	0.71	1.93	0.24
Cymbella turgidula	3	0.48	0.12	0.12	0.62	0.12		
Diatoma moniliformis	2			0.12	0.37	0.35		
Diatoma vulgaris	3	0.72	0.36	0.36	2.22	0.59	0.36	0.12
Epithemia adnata	2		0.12			0.24	0.12	0.60
Epithemia sorex	3	10.42	11.52	5.75	2.35	37.81	11.35	52.60
Epithemia turgida	3				0.12		0.12	0.24
Fragilaria bicapitata	2						0.12	
Fragilaria brevistriata	3	0.36		0.48	0.25	0.12		1.21
Fragilaria capucina	2	0.48	0.12	0.12	0.62	0.12	0.72	
Fragilaria construens	3	1.80	3.36	3.35	5.68	1.77	14.98	4.35
Fragilaria leptostauron	3	2.99	0.60	0.84	3.46	0.12	1.81	0.85
Fragilaria parasitica	2		0.36				0.12	
Fragilaria pinnata	3	2.75	0.96	1.20	2.96	0.24	2.90	1.21
Fragilaria tenera	2			0.24				
Gomphonema aquaemineralis	3	0.12			0.25			
Gomphonema clavatum	2	0.60	0.12	0.24				
Gomphonema micropus	2						0.24	
Gomphonema minutum	3	0.60	0.24				0.12	
Gomphonema olivaceum	3	0.12	0.84	0.24	0.62	2.24	0.12	1.57
Gomphonema parvulum	1	0.72		0.72	3.70	0.12	0.24	0.24
Gomphonema pumilum	3	0.48	0.24				0.48	0.12
Gyrosigma acuminatum	2							0.12
Hannaea arcus	3	0.24						
Melosira varians	2	0.60					0.12	
Meridion circulare	3	0.12						
Navicula aquaedurae	2				0.25	0.24		
Navicula bryophila	3		0.24	0.24				
Navicula capitata	2		0.48					
Navicula capitatoradiata	2	0.96	0.12	0.12		0.24	0.72	0.24
Navicula cincta	2				0.12			

Appendix B (continued)

SPECIES	PT	CFR 07 PRA	CFR 08 PRA	CFR 8.5 PRA	CFR 09 PRA	CFR 10 PRA	LBR 10.2 PRA	CFR 11 PRA
Navicula cryptocephala	3	0.24			0.12		0.12	
Navicula cryptotenella	2	19.28	6.72	33.17	27.41	11.43	0.24	8.83
Navicula decussis	3	0.12	0.12		0.12	0.12		0.12
Navicula gregaria	2	0.24						
Navicula ignota	2	0.12	1.20	0.24	0.25	0.47		0.12
Navicula lanceolata	2		0.12			0.24	0.24	
Navicula menisculus	2	0.36	0.24					
Navicula minima	1	0.12	5.52	0.36	0.74	4.71		2.06
Navicula pupula	2		0.48		0.25	0.24	0.12	
Navicula radiosa	3						0.12	
Navicula reichardtiana	2	2.87	0.36	1.08	0.37	0.71	3.14	0.73
Navicula tripunctata	3	5.51	0.60	1.44	0.37	0.12	3.14	3.75
Navicula trivialis	2	0.24						
Neidium binodeformis	2			0.12				
Nitzschia alpina	3				0.12			
Nitzschia amphibia	2	0.24		0.24				
Nitzschia archibaldii	2					0.24		
Nitzschia capitellata	2				0.12			
Nitzschia communis	1			0.24				
Nitzschia denticula	3				1.23			
Nitzschia dissipata	3	2.51	1.56	2.04	1.48	0.12	1.21	0.36
Nitzschia fonticola	3	1.32	0.24	0.12	0.49	0.12	3.62	0.24
Nitzschia hantzschiana	3		0.48	0.36			1.09	0.24
Nitzschia heufleriana	3	0.12		0.12	0.12		0.12	0.12
Nitzschia inconspicua	2	1.68	7.92	1.08	1.48	9.19	1.45	5.32
Nitzschia linearis	2	0.12	0.12	0.12	0.74	0.12		0.12
Nitzschia palea	1	0.48	0.24	0.36		0.24		
Nitzschia paleacea	2	0.48	0.24	0.24	0.37	0.47		
Nitzschia perminuta	3	0.24						
Nitzschia pusilla	1	0.12						0.48
Nitzschia sigmoidea	3			0.24				0.24
Nitzschia sinuata	3	0.12						
Nitzschia sociabilis	1	1.32		0.24	0.12			
Nitzschia sublinearis	2				0.12			
Nitzschia vermicularis	2	0.12						
Opephora olsenii	3					0.24	0.12	
Rhoicosphenia abbreviata	3	11.26	1.80	1.20	5.93	1.18	0.36	0.60
Rhopalodia gibba	2	0.24	0.12	0.12	0.12			0.24
Simonsenia delognei	2					0.12		
Stauroneis smithii	2				0.12			
Surirella angusta	1	0.24		0.12				
Surirella minuta	2	0.24			0.25	0.12		
Synedra ulna	2	0.48			0.49	0.12	0.12	

METRIC	CFR 07	CFR 08	CFR 8.5	CFR 09	CFR 10	LBR 10.2	CFR 11
Valves Counted:	835	833	835	810	849	828	827
Species Counted:	58	48	47	51	44	41	39
Shannon Diversity:	4.47	4.11	3.66	4.11	3.38	3.43	2.97
Pollution Index:	2.62	2.68	2.47	2.47	2.64	2.90	2.77
Siltation Index:	39.40	27.01	42.16	36.67	29.09	15.34	22.97
Disturbance Index:	4.07	3.00	12.10	8.27	2.00	1.33	1.09
Percent Epithemiaceae:	10.42	11.64	5.75	2.47	38.04	11.59	53.45

Appendix B (continued)

STREAM:	CFR	CFR	CFR	CFR	CFR	LBR	CFR
STATION NUMBER:	07	08	8.5	09	10	10.2	11
METRIC							
Total PRA PT Class 1:	3.11	5.76	2.04	4.57	5.06	0.24	2.78
Total PRA PT Class 2:	31.86	20.77	49.10	43.83	26.15	9.54	17.53
Total PRA PT Class 3:	65.03	73.47	48.86	51.60	68.79	90.22	79.69

Appendix B
Diatom proportional count data, Clark Fork Basin biological monitoring, August 4-8, 2001.
PT = Pollution Tolerance class number; PRA = Percent Relative Abundance. A letter "p" denotes species encountered during floristic scan, but not during count.

STREAM:		FTC	CFR	CFR	RKC	CFR	BFR	CFR
STATION NUMBER:		11.5	11.7	12	12.5	13	14	15.5
SAMPLE NUMBER:		1401I	0652J	0557R	1402I	0558X	0752V	0897S
2001 SAMPLING DATE:		8/6	8/6	8/6	8/6	8/6	8/5	8/4
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Achnanthes biasolettiana	3						2.51	
Achnanthes bioretii	3					0.24		
Achnanthes clevei	3			0.12	0.48	0.24	0.24	
Achnanthes lanceolata	2	2.46	1.85	0.96	1.81	0.84	0.72	0.97
Achnanthes minutissima	3	1.11	1.60	0.60	3.25	1.67	6.47	7.40
Achnanthes rossii	3				0.12			
Achnanthes subatomoides	3	0.25			0.12	0.12		
Amphora inariensis	3					0.12		
Amphora libyca	3				0.12		0.24	0.12
Amphora pediculus	3	2.09	5.93	4.33	0.48	1.79	0.72	1.46
Aulacoseira distans	3	0.49						
Caloneis bacillum	2	0.25			0.12	0.24	0.12	0.12
Caloneis tenuis	3			0.12				
Cocconeis pediculus	3	0.86	6.05	2.29	0.24	1.44	0.36	3.28
Cocconeis placentula	3	2.34	7.16	4.45	4.21	4.78	4.07	1.21
Cyclotella meneghiniana	2		0.25	0.24	0.12	0.36		0.12
Cymatopleura solea	2					0.24		
Cymbella affinis	3	3.57	0.12	0.12		0.48	8.38	0.73
Cymbella caespitosa	2				0.24	0.12	0.12	0.97
Cymbella elginensis	3				6.14	1.67		0.12
Cymbella mexicana	3	0.12			0.24			
Cymbella microcephala	2			0.24			1.44	0.49
Cymbella minuta	2	0.49			4.09	0.96	2.04	0.61
Cymbella muelleri	2				0.12			
Cymbella reichardtii	3	0.25		0.12				
Cymbella silesiaca	3	3.57	2.84	1.44	10.59	2.03	5.15	3.88
Cymbella sinuata	3	1.23	0.86	0.60	0.36	1.08	0.24	0.49
Cymbella turgidula	3	2.46	0.25			0.12	20.84	0.49
Diatoma mesodon	3				0.12			
Diatoma moniliformis	2	0.25	0.99	0.36	3.61	6.34	0.12	6.80
Diatoma vulgaris	3	0.74	0.25	1.20	2.29	0.48	0.12	0.24
Didymosphenia geminata	3				0.12		0.12	0.12
Epithemia adnata	2		1.23	0.60		0.48	0.84	0.12
Epithemia sorex	3	3.08	21.85	34.54	9.39	23.92	11.98	11.04
Epithemia turgida	3			0.48	0.96	0.12	0.12	0.73
Fragilaria brevistriata	3	0.99	1.73		0.48	0.96	0.84	1.46
Fragilaria capucina	2	0.12	0.12	0.96	0.72	0.96	0.84	1.70
Fragilaria construens	3	2.83	8.40	4.81	15.40	9.69	3.11	8.01
Fragilaria crotonensis	3					0.36		
Fragilaria leptostauron	3	0.49	1.11	1.08	2.77	1.79	1.80	2.55
Fragilaria mazamaensis	3				2.17	1.20	0.24	0.24
Fragilaria nitzschioides	3		1.36					0.24
Fragilaria pinnata	3	0.12	1.36	2.29	8.78	2.87	1.92	2.18
Gomphoneis eriense	3				0.48		0.48	0.24
Gomphoneis minuta	3				0.12		0.24	
Gomphoneis septa	3						0.24	
Gomphonema aquaemineralis	3	0.49						
Gomphonema clavatum	2						0.24	0.12
Gomphonema micropus	2			0.12				

Appendix B (continued)

		FTC	CFR	CFR	RKC	CFR	BFR	CFR
STREAM:		**FTC**	**CFR**	**CFR**	**RKC**	**CFR**	**BFR**	**CFR**
STATION NUMBER:		**11.5**	**11.7**	**12**	**12.5**	**13**	**14**	**15.5**
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Gomphonema minusculum	3				0.24		0.24	0.12
Gomphonema minutum	3	6.40	0.62		0.12	0.12	3.35	0.97
Gomphonema olivaceum	3	0.86	2.59	0.48	0.12	0.48	0.48	1.21
Gomphonema parvulum	1	1.23	0.49	0.12			0.12	0.49
Gomphonema pumilum	3	0.49		0.24	0.72	0.24	4.19	0.24
Gomphonema rhombicum	3				0.24		0.24	0.24
Melosira varians	2		0.12					0.61
Meridion circulare	3		0.37		0.12			
Navicula atomus	1					0.12		
Navicula bacilloides	3						0.24	
Navicula bryophila	3		0.12				0.12	0.24
Navicula capitatoradiata	2	1.97	1.36	0.24	3.85	1.79	1.68	9.34
Navicula constans	3				0.12	0.12		
Navicula cryptotenella	2	16.63	8.77	21.30	1.32	13.04	2.75	4.73
Navicula decussis	3		0.25	0.12				
Navicula detenta	3				0.12			
Navicula elginensis	3			0.24				
Navicula erifuga	2					0.24		
Navicula ignota	2	0.25	0.74		0.24			
Navicula lanceolata	2	0.12	0.99					0.12
Navicula libonensis	2	0.25	0.25	0.12		0.12		
Navicula menisculus	2	0.12			0.12			0.12
Navicula minima	1	0.49	0.74	2.41		0.24		
Navicula parabilis	2						0.24	
Navicula placentula	3						0.24	
Navicula pupula	2	0.49	0.12	0.24		0.48		
Navicula radiosa	3				0.36		0.12	0.12
Navicula reichardtiana	2	2.22	1.23	0.48	3.49	3.35	0.24	2.55
Navicula soehrensis	3		0.25	0.12				
Navicula tripunctata	3	7.64	3.09	3.73	0.36	1.67	0.24	1.58
Navicula trivialis	2		0.49					
Navicula veneta	1			0.60				0.12
Nitzschia acidoclinata	3						0.48	
Nitzschia alpina	3	0.25	0.12	0.12			0.72	
Nitzschia amphibia	2	0.12		0.12				
Nitzschia angustata	2							0.12
Nitzschia archibaldii	2	0.25	0.49	0.12				0.24
Nitzschia capitellata	2	0.37						
Nitzschia dissipata	3	6.03	0.62	0.48	0.12	2.39	1.44	3.52
Nitzschia fonticola	3	2.22	0.49	0.48	1.08	0.96	0.24	2.79
Nitzschia hantzschiana	3	1.11	0.12	0.24	3.01	0.72	0.24	
Nitzschia heufleriana	3		0.12	0.48	0.24	0.24		0.12
Nitzschia inconspicua	2	7.14	3.95	1.20	0.72	1.44	0.24	1.82
Nitzschia lacuum	3					0.24	1.20	0.49
Nitzschia linearis	2	0.25	0.25	0.36	0.12	0.12		0.73
Nitzschia palea	1	2.46	0.25	0.36	0.12	0.12		1.46
Nitzschia paleacea	2	1.48	0.25	0.24	1.20	0.72	0.24	2.43
Nitzschia perminuta	3				0.24			
Nitzschia recta	3				0.36			
Nitzschia sociabilis	1		0.49	1.20				0.24
Nitzschia supralitorea	2	0.49						
Nitzschia vermicularis	2					0.24		
Opephora olsenii	3			0.24				0.12
Rhoicosphenia abbreviata	3	7.64	3.70	1.08	0.24	2.51		3.28
Rhopalodia gibba	2		0.25			0.24	0.36	

Appendix B (continued)

STREAM:		FTC	CFR	CFR	RKC	CFR	BFR	CFR
STATION NUMBER:		11.5	11.7	12	12.5	13	14	15.5
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Simonsenia delognei	2		0.12	0.12				
Surirella angusta	1							0.12
Surirella brebissonii	2	0.25						
Surirella minuta	2	0.12	0.12	0.12				0.24
Synedra acus	2		0.25		0.12			0.12
Synedra ulna	2		0.49	0.48	0.60	0.36	3.47	1.09

STREAM:	FTC	CFR	CFR	RKC	CFR	BFR	CFR
STATION NUMBER:	11.5	11.7	12	12.5	13	14	15.5
METRIC							
Valves Counted:	812	810	831	831	836	835	824
Species Counted:	53	55	54	60	57	57	64
Shannon Diversity:	4.66	4.43	3.64	4.51	4.33	4.41	4.88
Pollution Index:	2.56	2.71	2.62	2.77	2.66	2.84	2.59
Siltation Index:	52.71	25.68	35.14	17.21	28.35	10.66	33.25
Disturbance Index:	1.11	1.60	0.60	3.25	1.67	6.47	7.40
Percent Epithemiaceae:	3.08	23.09	35.62	10.35	24.52	12.93	11.89
Total PRA PT Class 1:	4.19	1.98	4.69	0.12	0.48	0.12	2.43
Total PRA PT Class 2:	36.08	24.69	28.64	22.62	32.66	15.69	36.29
Total PRA PT Class 3:	59.73	73.33	66.67	77.26	66.87	84.19	61.29

Appendix B
Diatom proportional count data, Clark Fork Basin biological monitoring, August 4-8, 2001.
PT = Pollution Tolerance class number; PRA = Percent Relative Abundance. A letter "p" denotes species encountered during floristic scan, but not during count.

STREAM:		**CFR**	**BRR**	**CFR**	**CFR**	**CFR**	**CFR**	**CFR**
STATION NUMBER:		**18**	**19**	**20**	**22**	**24**	**25**	**27**
SAMPLE NUMBER:		0676U	0278Z	272AA	273AE	0901R	0903R	0905V
2001 SAMPLING DATE:		8/4	8/4	8/4	8/5	8/5	8/5	8/5
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Achnanthes biasolettiana	3	0.12	1.20	0.71	0.72	0.25	0.12	0.95
Achnanthes clevei	3				0.12	0.12	0.24	0.12
Achnanthes laevis	3							0.24
Achnanthes lanceolata	2	0.36	0.36	0.60	1.21	0.99		0.36
Achnanthes laterostrata	3						0.12	
Achnanthes minutissima	3	4.39	10.00	5.60	4.11	4.57	5.39	10.23
Achnanthes pusilla	3		0.48					0.83
Amphipleura pellucida	2							0.12
Amphora libyca	3							0.12
Amphora pediculus	3	0.95	0.12	0.36	1.69	1.73	0.73	1.31
Anomoeoneis vitrea	2							0.12
Caloneis bacillum	2	0.12					0.24	
Cocconeis neodiminuta	3							0.24
Cocconeis pediculus	3	2.49	0.24	0.71	0.60	3.58	3.30	1.07
Cocconeis placentula	3	2.02	7.23	3.81	5.68	8.28	8.81	6.90
Cyclostephanos invisitatus	2					0.12		0.24
Cyclotella comensis	3							2.62
Cyclotella meneghiniana	2	0.24	0.12	0.36	1.09	0.49	1.59	1.66
Cyclotella ocellata	3							0.12
Cyclotella pseudostelligera	2							0.24
Cymbella affinis	3	2.25	2.17	8.45	6.04	8.78	1.71	14.74
Cymbella caespitosa	2	2.14	0.12	4.88	4.83	0.25	2.82	1.43
Cymbella cistula	3		1.45	0.24				
Cymbella delicatula	3							0.12
Cymbella microcephala	2	0.47						1.90
Cymbella minuta	2	1.19	1.33	1.19	1.93	1.48	0.98	0.12
Cymbella prostrata	3			0.12		0.12		0.12
Cymbella reichardtii	3	0.24	0.24			0.25		
Cymbella silesiaca	3	4.63	3.61	2.74	2.42	1.36	0.49	1.19
Cymbella sinuata	3	0.59	1.93	4.88	3.26	2.97	0.86	0.71
Cymbella turgidula	3	3.32	1.93	6.31	3.26	5.93	0.49	8.32
Diatoma moniliformis	2	1.42		0.48	1.45	3.46	3.67	0.59
Diatoma tenuis	2	0.12						1.07
Diatoma vulgaris	3	2.61	0.24	2.02	2.66	1.61	2.57	2.02
Didymosphenia geminata	3	0.12						
Epithemia adnata	2						0.12	0.24
Epithemia sorex	3	10.32		0.95	1.21	2.47	17.38	0.24
Epithemia turgida	3						1.84	0.12
Fragilaria brevistriata	3	0.24	0.48	0.24		1.73	0.49	0.95
Fragilaria capucina	2	0.95	0.12	0.12			0.98	2.50
Fragilaria construens	3	3.91	0.84	0.24	1.21	2.72	4.41	4.28
Fragilaria crotonensis	3			0.60				
Fragilaria leptostauron	3	2.85	0.24	0.36	0.72	0.62	1.71	0.24
Fragilaria mazamaensis	3		0.12		0.24		0.24	0.24
Fragilaria parasitica	2							0.24
Fragilaria pinnata	3	1.19	0.12	1.19	1.09	0.62	1.10	1.43
Gomphoneis eriense	3	0.24	0.24	0.24	0.24		0.24	0.12
Gomphoneis minuta	3		0.24	0.12				0.12
Gomphoneis septa	3							0.12

Appendix B (continued)

STREAM:		CFR	BRR	CFR	CFR	CFR	CFR	CFR
STATION NUMBER:		18	19	20	22	24	25	27
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Gomphonema clavatum	2							0.12
Gomphonema gracile	2				0.12			
Gomphonema minusculum	3						0.24	0.71
Gomphonema minutum	3	3.20	3.13	4.52	4.23	8.53	2.45	1.55
Gomphonema olivaceum	3	1.30	0.12	0.12	0.48	0.25	0.24	
Gomphonema parvulum	1	1.78	0.24	0.71	0.48	0.62	0.24	0.48
Gomphonema pumilum	3	0.71	14.22	1.67	4.47	1.85	2.57	2.38
Gomphonema rhombicum	3		0.48	0.48		0.25		
Gomphonema truncatum	3		0.12					
Hannaea arcus	3							0.12
Melosira varians	2	0.36	0.24		0.48			
Meridion circulare	3			0.24			0.37	
Navicula atomus	1		0.12		0.24	0.12		
Navicula bryophila	3						0.24	
Navicula capitata	2				0.12		0.12	
Navicula capitatoradiata	2	12.81	16.14	16.43	14.37	9.64	11.51	4.40
Navicula contenta	2						0.12	
Navicula cryptocephala	3		0.12				0.12	
Navicula cryptotenella	2	3.44	2.17	2.98	2.17	2.10	1.47	0.95
Navicula decussis	3	0.12	0.12	0.12	0.36	0.25	0.24	0.36
Navicula elginensis	3							0.12
Navicula hintzii	3		0.48					
Navicula ignota	2		0.12					
Navicula lanceolata	2				0.12			
Navicula libonensis	2							0.12
Navicula menisculus	2		0.24	0.60	0.24	0.25	0.12	0.24
Navicula minima	1	0.24				0.25		
Navicula perminuta	2				0.12	0.12		
Navicula pupula	2	0.12			0.12			0.24
Navicula radiosa	3	0.12						0.12
Navicula reichardtiana	2	1.78	0.84	0.95	0.97	1.11	0.49	0.12
Navicula rhynchocephala	3				0.24			
Navicula tripunctata	3	1.42	1.69	2.02	1.21	1.61	1.71	0.36
Navicula viridula	2			0.12				
Nitzschia acicularis	2			0.12	0.24		0.49	0.24
Nitzschia amphibia	2	2.14	0.12	0.48	0.60			
Nitzschia archibaldii	2		0.96	0.71	1.57	1.48	0.98	1.19
Nitzschia denticula	3						0.24	
Nitzschia dissipata	3	1.78	3.86	1.19	2.05	1.98	1.22	1.19
Nitzschia flexoides	2							0.24
Nitzschia fonticola	3	4.51	4.94	4.05	7.85	2.97	1.47	0.95
Nitzschia hantzschiana	3	0.47	1.08	1.43	0.60	0.74	1.71	1.19
Nitzschia heufleriana	3			0.12	0.12	0.12		
Nitzschia inconspicua	2	0.71	0.72	0.24	0.60	0.87	1.22	0.95
Nitzschia linearis	2		0.12	0.12				
Nitzschia palea	1	1.42	2.41	2.26	0.72	0.87	2.20	0.36
Nitzschia paleacea	2	5.93	8.67	7.98	3.02	2.35	0.24	0.83
Nitzschia perminuta	3		0.24					
Nitzschia pusilla	1					0.25		
Nitzschia recta	3	0.12				0.12		
Nitzschia supralitorea	2			0.24		0.25		
Opephora olsenii	3		0.24				0.37	0.71
Rhoicosphenia abbreviata	3	3.56	0.24	0.36	2.29	1.11	0.49	0.48
Rhopalodia gibba	2						0.24	
Stephanodiscus minutulus	2					0.12		

Appendix B (continued)

STREAM:		CFR	BRR	CFR	CFR	CFR	CFR	CFR
STATION NUMBER:		18	19	20	22	24	25	27
SPECIES	PT	PRA	PRA	PRA	PRA	PRA	PRA	PRA
Surirella angusta	1	0.47						
Synedra acus	2		0.12			0.25	0.24	0.48
Synedra ulna	2	2.02	0.48	2.26	3.99	4.94	3.67	7.13
Tabellaria flocculosa	3							0.12
Thalassiosira pseudonana	2					0.12	0.24	0.95

STREAM:	CFR	BRR	CFR	CFR	CFR	CFR	CFR
STATION NUMBER:	18	19	20	22	24	25	27
METRIC							
Valves Counted:	843	830	840	828	809	817	841
Species Counted:	51	56	53	52	54	58	74
Shannon Diversity:	4.85	4.34	4.62	4.84	4.83	4.69	4.90
Pollution Index:	2.56	2.61	2.53	2.58	2.65	2.64	2.69
Siltation Index:	37.60	45.18	42.14	37.68	27.44	25.95	14.15
Disturbance Index:	4.39	10.00	5.60	4.11	4.57	5.39	10.23
Percent Epithemiaceae:	10.32	0.00	0.95	1.21	2.47	19.34	0.59
Total PRA PT Class 1:	3.91	2.77	2.98	1.45	2.10	2.45	0.83
Total PRA PT Class 2:	36.30	33.01	40.83	39.37	30.41	31.58	29.01
Total PRA PT Class 3:	59.79	64.22	56.19	59.18	67.49	65.97	70.15